# AGRICULTURE

OF

# NORTH-CAROLINA.

## PART II:

CONTAINING A STATEMENT OF THE PRINCIPLES OF THE SCIENCE UPON WHICH THE PRACTICES OF AGRICULTURE, AS AN ART, ARE FOUNDED.

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BY

EBENEZER EMMONS,
STATE GEOLOGIST.

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*To His Excellency*, JOHN W. ELLIS,

*Governor of North-Carolina:*

SIR: Although your station in life withheld your hands from the active and laborious duties of husbandry, yet, in the discharge of your former official duties, you were furnished with constant opportunities to acquire exact information of the state and condition of Agriculture throughout the State. It is no doubt for this reason that you have so frequently expressed the strong interest for the improvements in this department of labor, and the more general diffusion of information upon those subjects which are intimately related to it.

By your permission and advice I have been led to undertake the preparation of several works upon the Agriculture of the State. The first is designed to be preparatory to those which will follow, and although the subject matters are by no means easily treated, yet I am encouraged to hope I shall so far succeed as to present them in a form and in a language which can be understood by the common reader.

I am, sir,

Your obedient servant,

EBENEZER EMMONS,

*State Geologist.*

RALEIGH, *March* 1, 1860.

# PREFACE.

THE principles of Agriculture set forth in the following pages are designed for the use of Planters and Farmers of this State. The subjects involving the principles herein detailed, are not so fully treated of as in other works of a higher aim, and which profess to be scientific; but we hope that they belong to a class which may be regarded as the leading principles of Agriculture; and therefore, may secure the attention of those for whom they are designed.

In consequence of the fixed prejudices to change modes of culture, and the strong tendency to unbelief of promised advantages when modifications of a system of husbandry are proposed, it has happened that professional men have taken the lead and advanced forward, when the regular bred farmer has stood still. The lawyer, the physician, and merchant, men of capital, who have been disposed to retire from their professions have been generally more ready to follow new modes of culture, and to engage in somewhat more expensive experiments than the farmer. It is true, their example has not been followed immediately, and indeed, they have not always succeeded; but their results have often been so striking, as to arrest attention, and it has worked in some way or other to the advantage of agriculture; sometimes by exciting the pride or vanity of the regular bred farmer, who feels that he ought not to be outdone or outshone in crops or cattle; and has therefore, been led to attempt on his part to outdo a competitor, who has placed himself irregularly in the ranks of laboring men. By way of illustration, we may mention LIVINGSTON, who introduced *plaster*, by which the agriculture of New York was revolutionized. LIEBIG, a chemist, first prepared and recommended the use of the *superphosphate of lime*, which had a decided influence upon the progress of agriculture. The introduction of fertilizers of this class could not fail to suggest many others, and hence, a multitude of mineral substances have been tried with varied success.

The faithful reader of the following pages may probably observe that certain facts and principles are repeated in different parts of

the work; if so, it will be found that they stand in different relations, and hence, are possessed of a greater value; we are not always losers by repetitions, when we can present them under a new phase. We have prepared this work, because we considered it necessary to carry out the objects of the survey. It is intended to prepare the way for other works which require a knowledge of the facts and principles contained in this. Agriculture is commanding more attention than formerly. Products, which ten years ago were unprofitable, have become profitable, because of the greater facilities and a diminished expense in reaching the markets of the world. Every mile of railroad helps the farmer, as his products are heavy, and are often both heavy and bulky. He requires, therefore, more than any other citizen, *public facilities.* As the world now moves, time is doubly important, and to attempt to reach a distant market with flour, corn or cotton, with the old six horse or mule team, would be utterly ruinous. It was impossible to revive agriculture under the old dynasty, *inaction;* but the advantages of public improvements are now so strongly felt that very few remain to oppose them; the great care which now devolves upon this generation of active and influential men, is to direct them judiciously.

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## PART II.

# AGRICULTURE.

MARCH, 1860. E. EMMONS.

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## CHAPTER I.

General remarks. Obstacles which retard the diffusion of knowledge among Farmers. Errors often due to imperfect observations. Case in point relating to acid soils. How experiments to be useful should be conducted.

§ 1. AGRICULTURE is regarded as an art and a science. As an art, its practice comprehends the preparation of the earth for the reception of seed, and the mechanical state best fitted for the perfection of a crop.

As a science, it comprehends that kind of knowledge which relates to the structure and composition of vegetables, their adaptions to climate, soil, and the relation which any members of the kingdom hold to the forces of nature. The successful practice of the art, is more or less dependent upon agricultural science, though in the order of time, art preceded science. This fact may seem to contradict the foregoing assertion, nevertheless its truth may be made to appear from sundry considerations. In the first place, the practice of the art is founded upon the simplest observations when the soil was fresh from the hand of nature and rich in all the elements of growth, when nothing perhaps was required but to gather the fruit and watch the progress of the seasons.

When improvement was attempted more attention was required. The grafting of one kind of fruit upon another must have demanded a knowledge of the structure and functions of bark, stem and the circulation of sap. The success would depend upon a purely scien-

tific conception, which would suggest the proper artistic mode of procedure. Accident must frequently have promoted discoveries, but accident happens in vain to the man who neglects to think, and perceive the real nature of results and how they came to pass. Accident in the presence of GALVANI laid the foundation of the beautiful science of galvanism; the same accident in the presence of ten or a hundred other men may not have awakened a single idea beyond the naked fact.

Accident, therefore, though it may have done much for science as well as art, yet it is only when it has occurred under the eyes of thinking men; in them alone will be awakened the germ of a practical idea.

It is not to accident however that progress in science or the arts is expected. An unexpected result may and often occurs which is turned to account; still, it is by a train of systematized knowledge that agriculture must depend for its future progress. The more exact this knowledge becomes the more we may hope from its general diffusion.

§ 2. Governed by the foregoing views we have proposed to preface a series of agricultural papers by stating as fully as the nature of the subject demands the elements of scientific and practical agriculture. In former reports, we have not entirely neglected or overlooked this part of the subject, but to add to the value of our agricultural investigations, it seems that something more than a few isolated principles should accompany the reports. The public mind is now awakened to the importance of book knowledge as it has been called. Old prejudices and old practices are giving away, these should be replaced by something more sound or rational, or more in accordance with recently established principles. In agriculture there still remains much that is obscure or has not been satisfactorily explained. When a true reason can be given for modes of successful or unsuccessful culture, agriculture will then have attained its highest stage of perfection. But agriculture requires extensive knowledge, and it will happen when this stage has been reached, that agriculturalists will rank with the most learned of the professions. That it is progressing to such a stage we entertain no doubts; for most of the natural history sciences are constantly contributing their discoveries to this ultimate result. But for results so desirable, time is an essential element, and no one

should expect an immediate fulfilment when so much remains to be discovered and when no doubt, a great deal has yet to be unlearnt or must still bear a doubtful import.

§ 3. One of the great obstacles in the way of a general diffusion of agricultural knowledge, especially to the farmer who makes no claim to a scientific education, is the frequent occurrence of hard names or words. A book is often thrown down in despair when so much meets the eye which is unknown. How to get around this difficulty is not yet clear; it is a difficulty which is complained of even by persons who have no just right for complaint. Even a word so common as *ammonia*, perplexes many, and although it is frequently translated *hartshorn*, yet how this pungent vaporous body can play so important a part in husbandry cannot be comprehended. There is certainly a grain or two of common sense in this; for as ammonia is usually spoken of, it would seem unfitting that it should enter the structure of vegetables as *hartshorn*, and that it is hartshorn itself which is so important to vegetation, whereas, it is no such thing; it is only a body which contains a needful element which it furnishes by decomposition. Its properties are due to powers conferred upon the vegetable kingdom. Knowing this body as a powerful stimulant to the sense of smell, does not impart to us a property fitting the sphere it is said to fill. It is so with many other bodies whose names often occur, as sulphuric and nitric acids. Many points relating to these powerful bodies should be more fully explained, and no doubt much of the prejudice of common minds to book knowledge arises from a misapprehension of subjects. How, for example, can a person who has been told that *ammonia* and *nitric acid* or *aqua fortis* are fertilizers, but would at once question the validity of the information. Something more is necessary then, than to be told that certain bodies are fertilizers; they should also know the reason why they are so, and the conditions under which they become so. To understand these points, something must be known of the powers conferred upon the vegetable kingdom, as well as upon the state and condition under which simple or compound bodies become really fertilizers at all. A systematic treatise on husbandry requires that certain elementary facts relating to the origin or source of soils and nutriment of vegetables should be at least generally stated.

§ 4. The importance of established principles as they are considered in the present state of agricultural knowledge, induces us then to state somewhat in detail their practical bearing.

Facts differ from principles. The latter are deductions from the former. It is often the case that what are regarded as facts are imperfect observations. Principles which may be deduced from supposed facts may be, and often are, wrong. When practice is based upon observation, it is quite necessary we should not be mistaken in our facts. We may cite one or two examples of a mistaken theory based upon imperfect observation and an ignorance of the functions which the vegetable kingdom performs. Thus the idea of an injurious acid in the soil is the basis of the application of marl and lime to correct that condition, and the inference is, that the beneficial effects of marling *is due solely to the correction of acidity*. The acidity itself is founded upon the growth of *sheep sorrel, pine and other plants*, which impart the taste of sourness to the palate. Sheep sorrel, however, grows upon poor soil—not upon an acid soil, for it often grows around lime kilns, where it is impossible that an acid should exist at all. We have seen it growing with great vigor through a stratum of air-slacked lime two inches thick, where it had been thrown from a lime kiln. We have seen sheep sorrel also covering a dry hill-side which had become poor by cultivation; whereas, it is rare to see this plant growing in moist peaty grounds, where acids from vegetable decomposition are usually expected. The fact is, in all plants which impart to the palate an acid taste, we may be assured it is *not* due to an acid soil, but to the action of their own peculiar organization, and this acid will be found to exist under any condition in which the plant can be grown. The soil has really no agency in its production; for sow sorrel seed in white pure sand and water, with that which is free from acidity, and the sorrel will be acid; it is characteristic of the plant, and independent of the soil in which it grows. Yet marl is useful, though our notions of its action are erroneous; still the question is highly practical; it would govern our practice in the quantity to be used; for if it is merely wanted to correct acidity, a small quantity will suffice for that. Whereas, if it is maintained that it furnished directly or indirectly food to the crop, a much greater quantity will be required.

§ 5. Another instance of an erroneous view of the operation of lime was related a few years ago at an agricultural meeting by the President of a State Agricultural Society. He said, he had used lime on two different kinds of soil. 1st. On a sandy soil, and at a certain amount per acre. He could not discover the slightest beneficial effects. He therefore concluded lime was good for nothing for sandy soils. He then tried it upon a clay soil. This experiment too was a failure, as he could not perceive that his crop was increased in amount. His general conclusion, therefore, was that the benefits of lime had been greatly overrated.

Now both conclusions were erroneous, because all the facts of the case had not been investigated. In the first instance the conclusion that the crop upon the sand was not improved by lime was true, but it does not follow that lime upon sandy soils is always useless, that contradicts the equally good experience of others. The fact was, the sandy soil was in a great measure destitute of organic matter, and hence the failure. We do not stop now to state the reason in greater detail; this subject will be considered fully hereafter. In the second instance, the clay soil, the conclusion that the crop did not appear to be benefitted by marl was no doubt true, but the speaker appears not to have at all apprehended the cause; it was not because it was a clay soil, but because there was already enough lime in the clay, there being not less than five per cent. We find, therefore, that the result of simple experiment, though made by the President of an Agricultural Society, may entirely mislead a community when all the associated facts are ignored. It turns out that lime is a fertilizer only upon certain conditions; those conditions must be complied with. Where it already exists in the soil to a large amount, it can only be useful in a caustic state. In this condition it affects both the chemical and mechanical condition, but is not necessary to form certain combinations by which a fertilizing substance is, as it were, generated or in part formed.

Experiments then, to be useful, must be conducted with a knowledge of all the essential points which bear upon the results obtained. The nature of the soil must be understood—the general composition of the fertilizers employed. In other words the experimenter must know what he is about.

## CHAPTER II.

The difficulty of classifying soils systematically. Varieties of soils. Soil elements. Derivation. Composition of rocks which furnish soils. Weight of soils. Average quantity of silex in soils. Carbonate of lime in soils. Losses which soils sustain in cultivation well established. Temperature an essential element in productive soils. Soils of the Southern States remain *in situ*. Organic elements of soils. Inorganic elements, etc.

§ 6. Soils cannot be systematically classified. We may divide them so that, considered in the extreme, the strong lines of demarkation will appear quite distinct, as a clay soil and a sandy one, but these graduate into each other and the lines of demarkation disappear insensibly. So we find peaty soils, and in districts where chalk underlies the surface soil, we may distinguish a calcareous soil, but both kinds lose their characteristics by intermixtures of clay and sand. We may however, say with truth, of any particular locality, that it has an argilaceous, calcareous or sandy soil as the case may be. Such a statement should be made, but this does not amount to a classification. We shall not, therefore, attempt the arrangement of soils into a systematic classification; it will be sufficient to indicate in our nomenclature the predominant element, whether it is clay, sand, lime or vegetable matter. It is not, however, proper to omit the statement that sand or silex is the basis of all soils except those in which organic matter greatly preponderates, for, in clay soils silex still exceeds in quantity the clay, but still clay masks the silex, though it is less than one-half, and hence has to be treated as an argilaceous soil.

But the real nature of soil is not fully stated, by any means when they are merely referred *generally* to the preponderating element, there is left out of view certain elements which, so far as fertility is concerned, are quite as important, though they exist only in minute proportions. We shall, however, take the ground that all the elements of a soil are important, and take away entirely any one of them and its fertility will be affected for certain crops at least, if not for all.

§ 7. The soil elements are only few, when compared with the number of known simple bodies; thus, while the known elements amount to about sixty-two or three, only about thirteen or fourteen

play any considerable part for the benefit of the vegetable kingdom. The latter are embraced in the following list, viz: Oxygen, hydrogen, nitrogen, sulphur, carbon, phosphorus, the base of silex, or silicon potash, soda, lime, magnesia, clay or alumine, iron and manganese. Iodine and chorine also exist in plants and soils. Potash, soda, lime, magnesia are compounds of oxygen and a metal, whose names terminate in *um*—as potassium, sodium, calcium, &c. The first seven which stand in the list, are unmetalic bodies, the last seven are metals. Oxygen, hydrogen and nitrogen in their free or uncombined states, are aeriform bodies; the others are solids possessing different weights. The foregoing bodies or elements exist in the rocks which compose the earth's crust, not however as simple bodies, but in combination with each other, forming what are usually known as simple minerals. Thus, quartz, mica, felspar, hornblende, talc, serpentine, carbonate of lime consist of these elements, and furnish them when they decompose or disintegrate into soil. The foregoing minerals constitute the great mass of the earth's crust. To take an example of the number of elements which a simple mineral as hornblende furnishes may be seen by the results of analysis. Thus hornblende, felspar and serpentine are composed of

| | HORNBLENDE. | FELSPAR. | SERPENTINE. |
|---|---|---|---|
| Silex, | 45.69 | 66.75 | 43.07 |
| Alumine, | 12.18 | 17.50 | 0.25 |
| Lime, | 13.83 | 1.25 | 0.50 |
| Potash and Soda, | ..... | 12.00 | 12.75 |
| Magnesia, | 18.79 | ..... | 40.37 |
| Oxide of Iron and Manganese, | 7.32 | 0.75 | 1.11 |

A simple or homogeneous substance, therefore, furnishes many soil elements, and as rocks, such as granite, gneiss, mica slate, hornblende, are made up of several minerals in mixture, or are aggregates, we may see how a single rock furnishes all the essential elements of nutrition.

The rocks which are composed usually of simple minerals, yield one or two elements in excess: silex and alumine, and hence these necessarily predominate in most soils. Almost all of these minerals furnish other bodies in minute doses, potash, and soda, together with combinations of lime and silex, potash and soda with phosphoric acid.

The latter forms such small proportions that they were at one time set down as accidental and unessential soil elements, but now they are known to be all-important.

§ 8. The mechanical condition and weight of any soil depends upon the existence of the predominating element. Sandy soils have a loose porous texture while an argilaceous one has a close one, and may be impervious to water.

The weight of soils is dependent of course upon composition:

| | |
|---|---|
| A cubic foot of dry silicious soil weighs,* ........ | 111.3 pounds, |
| A sandy clay, ........................... | 97.8 |
| Calcareous sand, ........................... | 113.6 |
| Loamy clay, ........................... | 88.5 |
| Stiff clay, ........................... | 80.3 |
| Slaty marl, ........................... | 112. |
| A soil richly charged with vegetable mould, ...... | 68.7 |
| Common arable soil, ........................... | 84.5 |

The average weight is about 94.58, and when charged with water will weigh 126.6 pounds.

§ 9. Soils which are formed from the debris of rocks, contain a large though variable proportion of sand and silex. Of one hundred and forty-six soils of Massachusetts, the average quantity of silex is 71.733. This is insoluble matter. The soluble and that which is fitted ultimately to enter into the composition of vegetables is about 15 per cent., of which 2.075 is a salt of lime. The midland counties of N. Carolina furnish coincident results. But the eastern counties, which have extensive tracts of swamp lands, differ considerably from the foregoing. The silex and alumine in many large tracts, amounts to less than 50 per cent., and sometimes is even less than five, or indeed must be classed as a peat unsuitable to cultivation.

Of lime, which is so much talked about, and is truly an essential element in soil, it appears from hundreds of analyses, that it rarely exists in large proportions. Such is the case in the soils of New York, even where they overlie a limestone, its average quantity rarely exceeds one per cent., and in large tracts it scarcely comes

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* Dana's Muck Manual, p. 36.

up to one-half of one per cent. In the western States there is about 1.50 per cent. In 48 European soils, noticed by Dana, it is 1.860. European soils agree generally with American; all things, therefore, being equal, their treatment with fertilizers will be based upon similar rules. We must not, however, disregard the influence of climate and temperature. These are important elements in agriculture, but so far as the composition of the soils of all the great geographical divisions are concerned, their differences have arisen from cultivation mainly; in their natural state they were much alike.

§ 10. Soils are analyzed for the purpose of determining their constituents. Under long cultivation some of the important elements are so much diminished that fertility cannot be claimed for them. We shall show hereafter how soils become infertile, and what becomes of the fertilizing matter. The proof that soils actually part with certain elements essential to fertility has been fully ascertained and determined. This result is certainly due to chemistry, and it is a great result; for, for a long time the contrary was maintained, and even now many believe that by a rotation of crops and good manipulation, soils may be maintained for an indefinite period in a state of productiveness. So, also, it has been believed, and is still in cer- quarters, that lands thrown out to commons, or to remain a few years fallow, will recover their original fertility. The sooner, however, such opinions are abandoned the better, as they lead to an erroneous system of agriculture.

A destructive practice really grew out of the doctrine, it was the continued use of the axe and fire, followed by long fallows when exhaustion was nearly completed. It demanded extensive plantations, and had such a system of extermination of timber been followed in a more northerly clime, the loss of wood and timber would have become a severe calamity.

§ 11. I have observed that temperature independent of the composition of soil is an essential element in agricultural practice. It often determines the kind of crop as well as the season when it is to be planted. In England maize finds an incompatible climate, and hence, as a substitute for grain wherewith to fatten cattle, root crops as the turnip is resorted to. Maize germinates in a soil when its temperature is as low as 60°, and also when it rises to 105. Germination is however arrested when the temperture reaches 116–120. In tropical regions the order of things is somewhat changed.

So much heat exists in the period answering to our summer that wheat, barley and oats are sown in the coolest months. So in mountainous regions, temperature becomes the controlling element. In the latitude of the Swiss Alps in Europe, wheat ceases to germinate at 3400 feet which corresponds to the latitude of 64°.

| | |
|---|---|
| Oats, at 3500, corresponding to latitude, | 64° |
| Rye, at 4600, corresponding to latitude, | 67° |
| Barley, 4800, corresponding to latitude, | 70° |

In Northern New York at the hight of 2000 feet above the ocean, wheat is an uncertain crop, or is liable to be cut off by an early frost; while oats, barley and rye come to maturity. So far as these facts go, it appears that the solid masses of the globe as the rocks, have little influence upon crops; but at the same time cultivation never fails to produce its influence, that of impoverishing the soil.

I have shown in a former report that the soils of the Southern States are not only formed from the rocks of the country, but that they remain upon the place where they are formed or *in situ*. The proof may be found in every railroad cutting from Virginia to Alabama. Wherever a quartz vein penetrated the rock it remains unchanged in position, it presents the interesting and curious phenomenon of an irregular band which seems now to have been forced through yielding and soft materials. Quartz veins standing up for 20 feet unsupported except by soft yielding materials. It is rare to see any thing of the kind in New York or New England. There, at some former period such soft materials with their veins of quartz were swept off by a mighty flood of waters. This erosion no doubt extended deeply or down to the solid plane of rock. No flood however, has disturbed the debris of rocks in North-Carolina, and hence it is no doubt true that this debris is really one of the most ancient products of the globe, equaling in age the Silurian or Devonian systems; still there is no clue by which its age can be exactly determined, it is now a soil often 25 to 50 feet deep. This condition of the soil no doubt has some important influence upon its agricultural capabilities. The plough in many places must continue to bring up for years an unexhausted soil where the mass is penetrable. This new soil turned up by deep ploughing, however, is necessarily coarse, especially where it is derived from the coarse schists, as gneiss and mica slate, hence it requires before it is really

prepared to receive a crop to be exposed to the chemical influence of the air and the action of frosts whose effects are mainly to increase its fineness.

§ 12. Simple bodies enumerated in a foregoing paragraph seem to require a fuller notice, particularly as to their properties or functions as soil elements. When either of them is isolated they appear to be neutral bodies; that is, they manifest but little disposition to form combinations. Nitrogen and hydrogen would remain in contact with each other for ages without entering into combination. Oxygen and hydrogen never combine when confined together in a vessel. A force is necessary to effect it in either case. A flame however, unites them suddenly, attended with a violent explosion. When burnt in streams issuing from small orifices, they combine evolving great heat and intense light. The product of combination is water, and nothing else. Most bodies have a strong affinity for oxygen; and hence, it is an element common to most solids. The air or atmosphere is composed of oxygen and nitrogen, water, of oxygen and hydrogen, iron rust of iron and oxygen; potash, of oxygen and potassium; soda, of oxygen and sodium; lime, of oxygen and calcium. The general term for compounds of the metals with oxygen is, **oxide*, as oxide of iron, manganese, lead, copper, &c. Oxygen when isolated is always aeriform; and has never been condensed into a solid or liquid. It is the essential element in combustion as usually understood, and is the only body capable of supporting life by respiration. When the word oxygen occurs we can scarcely fail to be reminded of it agency in sustaining life, and for supporting combustion. From these two facts, we may proceed farther, and call to mind that it forms a great class of bodies, called *oxides*. Neither can we fail to consider that it changes the condition of all bodies with which it unites. Water is unlike oxygen or hydrogen. Oxide ot iron has no property in common with either of its elements.

§ 13. HYDROGEN, is the lightest body known, and is always aeiform except when in combination. It has neither taste or smell,

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* The word oxide, properly terminates in *ide* and not *yde*, because in framing the nomenclature, this termination was fixed upon; according to idiom it would be spelt *oxyde*.

and is never found in nature uncombined with other bodies. Although it exists in many bodies as oils, and those which are termed *organic*, yet water is the body in which it most abounds—not that its proportion is greatest in water, but the general diffusion of water over the globe and in most bodies, makes it the great source of this element.

§ 14. Nitrogen, is another aeriform body, neutral and of little power; it would seem almost destitute of affinty, for other bodies, if we judge of its perperties as it exists in the atmosphere. Indeed, though it has feeble affiinities, it is for that reason, an element of one of the most powerfully corrosive bodies known. Nitric acid for example is only oxygen and nitrogen, but who ventures to taste it the second time, notwithstanding we inhale the elements of nitric acid at every breath. What substance is more singular than ammonia, or harthorn, which is only nitrogen and hydrogen chemically combined. It will be seen in the sequel that nitrogen performs important functions in the soil.

§ 15. Carbon, is a solid. We feel relieved when a solid presents itself, something to be seen and handled. It is pure in the diamond; nearly so in anthracite coal, and in the purest charcoal. It has only a feeble disposition to combine with other bodies. Heat materially puts its particles in a combining state. It forms with oxygen, carbonic acid, an aeriform body sufficiently heavy to be poured from a tumbler. If poured upon flame it extinguishes it, showing that though one of its elements is a combustible and the other a supporter of it, that it is itself an extinguisher when applied to burning bodies, and hence has been and may be used to extinguish fires—when inhaled, it acts as poison to the system; and yet in all organic bodies it is a basis of support.

§ 17. The four preceding elements are often called by way of distinction, the organic elements of bodies; because all bodies which are organized are composed mainly of them. The following examples will show more clearly than any other statement, the fact alluded to. For example, hay, in 1,000 pounds, is composed of:

| | LBS. |
|---|---|
| Carbon, .................................... | 458 |
| Hydrogen, .................................. | 50 |
| Oxygen, .................................... | 337 |
| Nitrogen, .................................. | 15 |

in which is found 90 pounds of inorganic matter called ash, the product of combustion. Potatoes is composed of:

| | LBS. | |
|---|---|---|
| Carbon, | 440 | |
| Hydrogen, | 58 | |
| Oxygen, | 447 | |
| Nitrogen, | 15, | Ash 40 lbs. |

Oats is composed of:

| | | |
|---|---|---|
| Carbon, | 507 | |
| Hydrogen, | 64 | |
| Oxygen, | 367 | |
| Nitrogen, | 22, | Ash 40 lbs. |

Wheat is composed of:

| | | |
|---|---|---|
| Carbon, | 461 | |
| Hydrogen, | 58 | |
| Oxygen, | 434 | |
| Nitrogen, | 23, | Ash 24 lbs. |

The constituents of animal bodies are quite different, though the same elements are usually found. Thus in lean beef blood, white of eggs, there is found:

| | |
|---|---|
| Carbon, | 55 per cent. |
| Hydrogen, | 7 |
| Nitrogen, | 16 |
| Oxygen, | 22 |

The propriety, therefore, of calling these four elements organic is not improper; it is true, however, that inorganic matter is always present. It seems to be necessary wherewith to form a species of skeleton, especially in such bodies as hay, oats, and wheat. In animal bodies, as hair and wool, sulphur is an important element, as well as phosphorus. In the solid structures, as bone, phosphorus, an element of the mineral kingdom, is always present in the largest proportion.

All good soils have their organic parts. When, therefore, the organic constituent of a soil is referred to, we are necessarily re-

minded of the fact that it consists of these four elements, carbon, oxygen, hydrogen and nitrogen, or that it may be resolved into them.

It is not to be concealed, however, that there are numerous bodies belonging to the organic kingdoms in which nitrogen is absent, as starch, gum, sugar, and the essential oils.

§ 18. Sulphur is a well known substance, of a yellow color, and a faint, peculiar odor. It burns with a pale blue flame, giving off at the same time a pungent suffocating vapor, which consists of oxygen and sulphurin combination. One pound of sulphur will make three pounds of sulphuric acid, or oil of vitrol. Sulphur is present in many substances. Mustard seed contains it in a large proportion; it is also always present in eggs, and which in consequence blackens silver; in wheat it is present, particularly in its gluten; also in lean meat, and in hair and wool, in which it forms nearly one-twentieth of their weight. From its constancy in the vegetable and animal kingdoms, it might be inferred that its application to the soil would be attended with favorable results. It is however, a striking example, illustrating numerous other cases, that in a simple condition it is not at all fitted to fulfil the office of a fertilizer, although it is not entirely insoluble in water. It may be used, however, beneficially in its simple state for the purpose of protecting vegetables from the attack of insects, as turnips, cabbages, &c.

But the sulphur of organic bodies, as hair, wool, mustard seed, is derived from salts which contain it; gypsum furnishes it; and other sulphates, as the sulphate of soda (glauber salts) sulphate of ammonia, etc. In this fact we find an illustration of the power of organic bodies to appropriate elements which are locked up in chemical combinations. Nothing is created in the vegetable tissue; it is only possible for it to decompose and appropriate such bodies as they require in growth, and each organ performs an independent office, and takes only that which its constitution demands. Thus the chaff of wheat differs in composition from the enclosed grain; and the hair differs in composition from the skin, upon which it is supported.

§ 19. Phosphorus is a yellowish, waxy substance, extremely inflammable, and even consumes at the ordinary temperature, but does not burst into a flame except its temperature is slightly ele-

vated. Friction upon a rough board sets it on fire. The common lucifer match is a good illustration of the fact, and the vapor given off in the act of combustion is composed of oxygen and phosphorus.

It is generally diffused in the organic kingdoms; in certain parts, as bones, it is far more abundant than sulphur in other tissues. It is contained in the substance of brain. Wherever a compound word, as *phosphate of lime*, phosphate of soda, etc. occurs, they will at once suggest to the mind of the farmer the combustible substance, *phosphorus*, or it may be the *lucifer match;* but as in the case of *sulphur*, the simple body *phosphorus* connot be employed directly as a fertilizer. Combinations of it must first be formed with oxygen, and then the acid thus formed must combine again with bodies which are called bases, as lime and potash. These form the base with which a *salt* is the final result. In the condition of a salt then, which is a body composed of an acid and a base, both sulphur and phosphorus are brought into a condition in which they may be employed as fertilizers. The composition of the salt is indicated by its name. Sulphate of lime, phosphate of lime, nitrate of lime, the latter indicating the presence of *nitrogen*, and by going back a step, it will be understood that nitric acid is implied, a compound of nitrogen and oxygen.

§ 20. The simple minerals from which soils are mainly derived, are felspar, hornblende and trap mica serpentine, talc, carbonate of lime. Their composition which has been given shows what elements they respectively furnish for the soil. Silex, which we find in the condition of sand, is a common product even of serpentine. But of the others we find felspar furnishes potash and soda, and one kind of felspar furnishes lime. Serpentine and talc abounds in magnesia, and so, also, certain kinds of limestone, particularly those called dolomites. Hornblende furnishes lime and but a trace of potash or soda. Hornblende is, however, generally of a dark green color, a color which is mainly due to iron, and hence soils derived from hornblende and trap, which is also dark colored, are generally red, for the reason that the iron when set free from its combinations, takes more oxygen and forms thereby a red peroxide of iron. When we find a soil derived thus from hornblende, and knowing also the composition of the mineral, we safely infer that the soil will contain a sufficiency of lime. A felspar soil is often gray, but

when iron is present in one or more of the elements of granite, it will change to a red which indicates a better soil than the gray. Granite soils are often very silicious, in which case they are coarse and poor or meagre in consequence of the great excess of quartz in the granite. The granite soils of North-Carolina, however, are generally very good, or are less meagre than in many other parts of the United States. Where felspar and mica predominate over the quartz element in granite, the soil resembles an hornblende soil in color, and in composition we may expect a larger per centage of potash.

Hence we obtain approximately several important facts relative to the composition of a soil when we have ascertained its origin. It will appear also, that this information may be obtained with greater exactitude in the Southern than in the Northern or Western States, where the soil has been transported to a distance from its parent bed.

§ 21. It has been stated that the original source of nutriment for the vegetable and animal kingdoms may be traced back to the rocks and minerals; it is still required that we also show as correctly as possible how the seemingly insoluble debris of the globe's crust becomes food, or is fitted for its high and important function. The fact itself is based on observation and experiment. For example, the process of disintegration goes on under onr eyes. We see rocks crumbling to a coarse powder which becomes by the continuance of atmospheric action still finer. If in any stage the composition of the rock is determined by analysis, it is found to consist of similar elements. But still the debris may and often does lose a portion of the mass, by solution. Granite contains in its felspar, potash or soda; both substances are finally washed out by water, or are perfectly set free from their combinations, and become soluble matters in the soil nnder other chemical states; those for example, which are called organic salts of potash or soda. We are required to look upon all the solid parts of the earth as in a state of change; every particle is in motion, nothing at rest. Some componnds it is true, are much more stable than others. Quartz for example, when unmixed with other bodies, appears to us stable. But felpar and mica are constantly undergoing change. The same may be said of hornblende, trap, mica, serpentine, talc, carb. of lime, etc. A double change is in progress. 1st, the mass is mechanically divided; and

2d. It is changed chemically. A piece of felspar, hornblende, or trap splits into thousands of particles. The surface is thereby greatly increased. In this condition the carbonic acid of the atmosphere acts upon its potash. This aids greatly in breaking up the affinities between the silex and alumine, and the consequence is that in the masses the silex chrystalizes out; the bond that united all the elements of felspar and formed an homogeneous mass is broken. In the original compound as felspar, the mineral was a silicate of alumine and potash, soda or lime, but carbonic acid having combined with one of the alkalies and formed a carbonate instead of a silicate, both the silex and alumina are set free, and the particles of silex will come together, and those of the alumine also. In the first mineral we perceive the grains of quartz or flint, and in the latter the pure clay. Molecular force, as it is called, brings together like particles. Under the operation of these molecular forces, felspar will not be reformed, though all the elements are present at one time; but in process of time all the carbonate of potash is dissolved out. An ultimate result which is quite obvious from inspection of beds of decomposing granite is the finding of a pure white bed of clay, called porcelain clay, intermixed with fragments of quartz, together with nodules of flint, as they would be called, and which are often hollow and their interior lined with fine crystals of quartz. The nodules are derived from the silex of the felspar, which was in combination with the alumine and potash. In this condition we see a perfect change of state. Analogous changes are in progress all the time.

§ 22. From the foregoing it may be seen that lime, potash, soda, silex, etc., are originally rock constituents, which by a process of decay become parts of the soil, and thereby accessible to the roots of plants. So also sulphur and phosphorus belong to the common compounds of the earth's crust. The first is extremely abundant in a class of bodies called *sulphates* or *sulphides;* combinations of metals with sulphur, as sulphuret of iron, so generally diffused in nature. It is known to be present by heating the body, when the peculiar bluish flame appears, accompanied with the suffocating odor of sulphur. Phosphorus, though less common, is probably always diffused through granite, but it is known to be more constant and more abundant in that class of rocks, called *trap*, in which also potash and other alkalies are constituents. Hence, as

trap, when it decomposes, furnishes an aluminous basis for a soil, and is at the same time impregnated with sulphur, phosphorus, and the alkalies, their soils are eminently adapted to the wheat crop. The gluten of wheat requires sulphur and phosphorus, as well as potash in certain combinations.

The organic constituents of the soil exist also as mineral bodies in the soils, and also rocks; oxygen in combination with all the elements of soil, hydrogen in water, and nitrogen in the nitrates, and the atmosphere diffused in the soil, where it is an active body, ever ready to form ammonia with hydrogen when water is decomposed.

§ 23. A substance which is not simple requires in this place a further notice, because its office is an important one in the vegetable economy; it is carbonic acid. The atmosphere is regarded as its source. It is, however, generated in the soil. Its solvent properties are among its most important properties. It is, notwithstanding, a feeble acid, and a feeble solvent, water charged with it dissolves rocks, and the indispensable compound, *phosphate of lime*, is dissolved by it, and being thereby brought into a soluble state by water, it becomes accessible to the roots of plants when diffused in this menstruum. In the atmosphere it forms only one two-thousandth part. It is maintained that leaves absorb it from the atmosphere, and obtain thereby the carbon required to build structures. Still, water in the soil holds it in solution, and from this source it is furnished in a direct way to the vegetable. It is also furnished to growing plants by peat, and the changes which organic matter undergoes in the soil; there is, therefore, an aerial source from which the leaves or upper structures of plants obtain it, and a sub-aerial source from whence the vegetable gets it by the roots. The latter are the channels by which the former may feed it to his growing crop. The organic part of the plant, that in which carbon is so abundant, is that which is consumed in combustion. The products are all volatile, and hence, are dissipated. It is by far the heaviest and most bulky part of the vegetable. That which is left after combustion is the inorganic part, and consists of lime, silex, potash, magnesia, soda, iron, etc.

## CHAPTER III.

The organic part of a soil and variety of names under which it is known, changes which it undergoes, and the formation of new bodies by the absorption of oxygen. Fertilizers in North-Carolina. Green crops. Mutual action of the elements of soils upon each other. Composition of one or two of the chemical products of soils showing the source of carbon in the plant.

§ 24. The organic part of a soil consist apparently of carbonaceous matter, and taken as a whole, it is the brown or blackish part, and which is consumed when ignited. Its appearance, indeed, is due to a species of combustion which is carried just far enough to char the vegetable matter. In warm climates it is nearly all consumed, while in cold it constantly accumulates, and forms at the surface a coat of blackish mould. The term organic applies to this part of the soil. On the mountains of this State it is often more than a foot thick. In the swamps of the eastern counties it is often ten feet thick, while in the midland counties it is only sufficient to give a brown stain to the surface. It does not seem to accumulate in consequence of a slow combustion, or as it may be termed *decay* which takes place.

In common language, the organic part is known under a variety of names, as *humus*, *mould*, *vegetable mould*. It is, however, a complex substance, and is constantly undergoing changes which promote vegetation. Chemists have obtained several distinct substances from it. It is really a mixture of organic and inorganic bodies. A portion of the organic matter is free, that is, it is uncombined with the inorganic part. Other parts are in combination with lime, magnesia, iron, potash, soda, &c. The latter are soluble, and also fertilizing matters, and play an important part in vegetation. The cause of this intermixture of organic and inorganic matter is to be traced to its origin. Thus, organic matter being the debris of the vegetables which had grown upon the soil, it must necessarily contain also the inorganic part which belonged to the living vegetables. From this fact it may be inferred that this matter is, in the proper proportions, to be employed by any subsequent crop.

§ 25. Vegetable Matter after death passes through a series of chemical changes, which gives origin to the numerous compounds

found in organic matter. These changes are due mainly to the absorption of oxygen. The first substance formed from woody fibre after the death of the plant, is *ulmic acid.* Another portion of oxygen changes ulmic acid into *humic acid;* and the last is changed into *geic acid;* on a farther oxydation it passes into *crenic acid;* and finally by the same process into *apocrenic acid.* In an old soil, all these bodies exist simultaneously. The most important, or those which are immediately active, are the three last, geic acid, crenic and apocrenic acid. All the foregoing bodies are the products of the decay of plants, when exposed in the soil to air and moisture. They cannot be distinguished by sight, and the whole mass is simply a homogeneous brown substance. But it is richly charged with the elements of fertility.

We may omit the details respecting the chemical constitution of these bodies. It will be sufficient to state in this place, that they are feeble acids; and yet possess considerable affinity for inorganic matter, lime, magnesia, ammonia, potash, soda, iron, etc.; so much so as to combine and form with them *salts*, which are at once in the proper state to be received as nutriment into the tissue of growing vegetables. This organic matter, however, is remarkable for its affinity for ammonia; the result, therefore, is that this important substance may be detected in vegetable mould, though it may be chemically uncombined with the foregoing acids; it may be present as a mixture, yet being present, it will be disposed and ready to combine with the crenic and apocrenic acids, in both of which nitrogen may be always detected. Organic salts, formed by the union of organic acids, with lime, magnesia, potash, ammonia, etc, are the proper food for plants; and hence, it will be a maxim with the farmer to take such measures as the nature of those substances require to increase it upon all occasions which occur. The greater the amount of these salts in his soil, the greater his crops.

§ 26. From the foregoing statements we may deduce the following principle, that *there is a mutual action of the organic and inorganic parts of the soil upon each other, and that to this action fertility is, in a great measure, due.*

In order that these mutual actions may be better understood, we proceed farther and state, that those substances which are called silicates, have but a slight if any tendency to act upon each other. They are, however, gradually decomposed by carbonic acid, the

effect of which is to form with the base of the silicate a carbonate. Thus in the case of granite and similar compounds, the felspar and mica which are silicates, are slowly decomposed, and the alkali, as potash, or alkaline earths, as lime and magnesia, or even iron and manganese of the rock, lose their silica, or are disengaged therefrom; and the carbonic acid combines with them. These being soluble compounds, are liable to be washed out and carried to the sea, while the insoluble silicate of alumina, or its pure form, remains behind. The consequence of this is, that the soil is relatively richer in clay than before, and the longer the chemical changes are going on, the larger the quantity of clay in the soil; and it is agreeable to experience that soils become stiffer by cultivation. By this process they become less adapted in the course of time to certain crops in consequence of this change of constitution. Large districts which once grew the peach luxuriantly, seem to have lost in part the power or ability, or, at any rate, the peach tree does not thrive so well in the oldest districts of New York and New England, as it did in the early period of their settlement. It is not possible probably to be satisfied fully with respect to the cause why the peach is cultivated with difficulty, but the fact that the soil by cultivation becomes more close and compact, may be remotely connected with the change we have stated. It has been attributed to a change of climate, but it is not true that the climate has changed, and hence we are disposed to refer the change in question to a change in the soil.

§ 27. In North-Carolina the natural supply of fertilizers exists in the marls of the lower counties, together with the organic matter of the swamps and bogs. The two exist often in juxtaposition. Experience has proved that marl applied to exhausted lands is often injurious. Now this exhaustion extends to the organic matter, though it also exists in its inorganic also. But experience further proves, that however large a quantity of the latter is applied, little benefit is secured so long as the first deficiency exists. We may see the reason why no organic salts can be formed in the absence of organic matter. The inorganic matter cannot find the proper elements with which to combine, and which the constitution of the vegetable requires. The practical inference is, that marls should be composted with organic matter, as leaves, straw, and weeds, which are free from seeds, or anything which has lived. Or, an-

other plan may be pursued—supply the organic matter from a green crop, as a crop of peas, ploughed in. In certain parts of the State, clover or buck-wheat may be resorted to. The gain arising from the latter practice, arises from the ability of these crops to take from the atmosphere the organic elements, and deliver them to the soil, a process over which the planter or farmer has no control, except the institution of means. Under many circumstances, the organic matter may be supplied more cheaply by sowing seed than by composting.

The importance of organic matter in soils has been sustained by the experience of ages; but there was a time when this point was denied by the ablest Chemists of the age. It was maintained, that the ash or the inorganic part gave to the soil all that was important, and hence certain practices were recommended which were in accordance with this theory, such as burning manures, burning turf and the like. Happily, this question has been set at rest, and the best Chemists admit those views which the experience of ages has confirmed independently of chemistry.

§ 28. But the point which bears more immediately upon the principle respecting mutual actions, comes in play subsequently to the decomposition of the silicates; which, so far as inorganic matter is concerned, are inert; but the lime and alkalies once freed from their original combinations with silica, becomes fitted to act at once upon organic matter, and form with it salts. This decomposition may take place where no organic matter exists by the carbonic acid of the atmosphere, but it happens that organic compounds furnish also carbonic acid to the soil; for it is displaced when carbonate of lime or potash is acted upon by an organic salt. Crenic acid, acting upon carbonate of lime, sets free the carbonic acid, and this, in its turn, acts upon the silicates to decompose them, and thereby sets the alkalies and alkaline earth also free. There is then a double mutual action, as it were, constantly going on in the soil, by which nutriment is furnished to the crop. Some physiologists maintain that the *presence of a living body*, as the root of a growing plant, effects decomposition similar to the action of sulphuric acid in converting starch into sugar. However this may be we are inclined to believe that the root has power to act and effect changes upon the elements of soil which are unknown in the laboratory of the chemist; and many substances which are insolu-

ble by chemical agencies, become soluble by the action of the roots of vegetables.

§ 29. The foregoing facts and principle do not change at all the action of the farmer; they go to sustain his practice in providing fertilizers by means of composts, formed by mixing the organic and inorganic bodies together, and for the purpose of giving them time and opportunity to effect those chemical changes, of which we have spoken. These never fail, while fertilizers in other states do. The foregoing are some of the chemical changes which take place in the soil, and which are mostly due to the presence of organic matter. All the facts go to prove the importance of organic matter, and the necessity, therefore, to supply it when from any cause it is wanting or deficient in quantity.

§ 30. In addition to the lime and other mineral bodies which the organic salts furnish to plants, it is plain that *carbon* is also one of the elements supplied. To make this plain we annex the composition of one or two of these organic bodies. Humate of ammonia consists of:

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|---|---|
| Carbon, | 64.75 |
| Hydrogen, | 5.06 |
| Oxygen, | 26.22 |
| Nitrogen, | 3.97 |

Humate of ammonia, it will be perceived, contains more than half its weight of *carbon*, which may be taken up in the circulating sap.

Humic acid is composed of:

| | |
|---|---|
| Carbon, | 65.30 |
| Hydrogen, | 4.23 |
| Oxygen, | 26.82 |

It will follow, from the foregoing, that carbon, which forms the largest part of a vegetable, is not derived entirely from the atmosphere. The soil, through the medium of the roots of the plant, furnishes at least a part of this essential element. In certain plants, as wheat, rye and oats, it is very possible that all the carbon is derived from the soil; while in beans, clover, lucerne, etc., a large proportion may be derived from the atmosphere.

## CHAPTER IV.

The mechanical condition of soils differ. Circulation of water in the soil with its saline matter. Capability of bearing drouth. How to escape from the effects of drouth. Temperature of soils. Influenced by color. Weight of soils, etc.

§ 31. The mechanical or physical conditions of soils differ according to their composition, and these physical differences must not be disregarded. It is well known that a clay soil contains under ordinary circumstances, more water than a mixture of clay and sand, and much more than sand alone. This fact may or may not become a serious injury to growing crops. It will depend upon the season. If it is very wet serious injury may be expected, or if it is very dry the crop will suffer, but not in the same way. All surfaces, whether composed of clay or sand, become dry by the evaporation of water, and the evaporation not only effects the surface but extends to a great depth; water seems to rise up to the surface from beneath to supply the waste. In confirmation of this view it is not uncommon to find a saline matter upon the surface in dry weather, which has been in solution in the water brought to the surface by this process. In many places in Wake county, N. C., the naked soil in ditches is covered with an incrustation of sulphates or iron and alumine, an astringent salt injurious to vegetation. This incrustion is formed only when there is a drouth; it is a gradual process. In countries where a whole season is dry, the soil becomes whitened with salts. Rains dissolve them and they sink again into the soil, though a portion will be carried away by water. An effect of a drouth upon a clay soil is to cause a shrinkage of the mass. It will then become still more difficult for roots to penetrate it, and hence, when drouth occurs early in the season, the crop is starved for want of nutriment, the roots cannot spread through an impervious mass. But sand simply dries without diminishing its bulk, but this process takes place with greater rapidity than upon clay soils, the latter being close and more retentive of moisture than the former.

§ 32. The rise of water to the surface from beneath, is familiarly illustrated by the putting of water into the saucer of a flower pot; its rise to the surface is well known. Flower pots are watered with

common rain water or charged with fertilizing matter which is conveyed to the roots. In long continued drouths when the water rises from a depth of 4 or 5 feet, instead of carrying up matter compatible with the nature of the plant, the astringent salts take their place, injurious effects to vegetation take place in addition to those which arise directly from the want of rain. These injurious salts are easily corrected by the use of lime or marl. When they reach the neighborhood of the roots if lime is present, it will decompose the salts and form gypsum. Fruit trees which send their roots deeply into the soil are often injured by the presence of these salts. From the foregoing facts it is evident that the subsoil should be examined for poisonous salts, and when the ditches or deep layers are exposed in cuttings for roads, and should become partially incrusted with astringent salts, it will be important to institute means for correcting this condition of the deep subsoil.

§ 33. The foregoing remarks apply to those varieties which are purely *clay* or sand. Composition may modify results materially; if for example a soil whose composition retains a preponderance of clay and yet has a due admixture of organic matter and lime, its ability to stand a drouth is greatly increased—for organic matter and lime not only retain moisture strongly, but they affect the texture favorably, and counteract the tendency to excess in shrinkage.

§ 34. As drouths in North-Carolina are much more injurious than excess of rain, it becomes a question of importance to know how to guard against their effects. The first point to be attended to, is to drain deeply. This will affect gradually the texture of the clay; it will become more porous, while its natural affinity for water will not be diminished; that is, it will be sufficiently retentive while the excess of water will be drained off. Clay may be regarded as requiring a specific amount of water; but at the same time its capacity for receiving and holding a greater quantity than this, is proved by experience. Another change may be affected by the free use of organic matter, which, when mixed with the soil, makes it porous. In the cultivation of not only clay soils, but sandy ones, crops should be planted as early as possible, that the surface may be protected by the shade of the growing crop. To be able to plant early, in clay soils especially, the water must be disposed of by drainage. Two weeks may be saved in many cases by drainage; that is, the land will admit of the plough two weeks earlier

in drained, than in undrained lands. Give a crop of corn two weeks more of growth than another piece eqnally well prepared, and the former will live through an ordinary drouth without injury, while the latter will not become half a crop.

§ 35. Absorption of moisture from the air takes place principally during the night, and unabsorbative power is less in sandy than clayey soils. This respite from heat, which causes so much evaporation during the day is of the highest importance. Even when dew does not fall, soils take a small quantity of water from the atmosphere. A stiff clay, it is said, sometimes absorbs one-thirtieth part of its own weight. Dry peat will also absorb nearly as much, but its power depends upon its condition; if very fine it absorbs more than clay; if coarse, less. The best condition of a soil is without doubt a mixture of clay and organic matter, where it is necessary to guard against droughts.

§ 36. The surface temperature of soils differ according to their composition. Water in all soils favors a low temperature because the evaporation carries off heat in the invisible vapor which rises from the surface. So long as an active evaporation goes on the surface continnes cold, hence in swamps and bogs where the supply is inexhaustible, very slight changes only occur during the summer. When the surface becomes dry it begins to rise, and if the air is only 60° or 70° in the shade, the soil will absorb and accumulate heat and may rise to 90° or 100°.

Color has much effect upon temperature. The darker the color, all things being equal, the greater is the absorbative power. The correctness of the common opinion with respect to the natural coldness of light colored clay soils is correct.

§ 37. It is stated by good authority that the amount of evaporation from an acre of fresh ploughed land is equal to nine hundred and fifty pounds per hour for the first and second days after plowing. The rapid evaporation diminishes every day. Evaporation begins again by hoeing, but the moist surface thus exposed has other functions besides the evaporative one. Moist surfaces are much better absorbents of ammonia from the atmosphere than dry ones, and one of the most important effects of stirring the soil often, arises from its increase in absorbative power. Water in the soil is disposed of by forest leaves or by the vegetable kingdom. A single tree 8½ inches in

diameter and 30 feet high expired from leaves in 12 hours 333,072 grains of water.

§ 38. An acre of woodland evaporates 31,000 pounds in 12 hours. During the summer, embracing 92 days, the whole amount of evaporation will amount to 2,852,000 pounds. Forests and vegetation generally largely aid the disposal of excessive water in the spring. Water of course accumulates in the soil during winter. Our wells receive their supply and springs have their sources of water replenished.

It is true, however, that the removal of forests presents a seeming anomaly, for where large tracts of country are shorn of their trees and forests, there the head-waters of our rivers fail or diminish. Evaporation is greatest from a shorn surface, and a country is on the road to ruin when its woodlands are mostly destroyed or consigned to the axe.

But woodlands require a change. Rotation is as necessary to the forest as to the successive crops of the farmer. We see this in the death of pines over large areas of this State. The idea that death was caused wholly by insects is fallacious. In it we see, in part at least, a natural effort to change the kind of vegetation. Oaks and hickory replace the pines. For hundreds of years pines had been the staple products of large tracts in this State. Is it therefore remarkable that a light soil containing the true pabulum of life for the pine, should have been nearly exhausted and the pine should have thereby become weakened and more liable to disease than formerly?

§ 39. The absolute weight of different soils is also variable. A cubic foot of clay, with its moisture, weighs about 115 pounds. The same quantity of damp sand 141; while peat, with its water, weighs only about 81 pounds. The weight of soils affects the labor of tillage. More force is required to lift a sandy soil than a clay. But the texture or compactness of an undrained clay soil more than makes up for its less weight.

In every point of view the farmer is encouraged to ameliorate the mechanical condition of his plantation. The first point requiring attention is its water or drainage, for when a soil is water soaked, good crops are only to be made in the most favorable season.

A subsoil of clay beneath sand is ameliorated by draining, though the top may appear to be sufficiently dry; for the clay may be

regarded as a reservoir of water, just as the filled saucer beneath the flower pot.

§ 40. We may recognise in all these facts two currents which may be found in soils; a downward current, which disposes of surface water, and an upward current, when the surface water has become exhausted. This arrangement is a wise one, for if there were no upward currents plants would perish, both for want of nutriment and water during drouths. This result would be far more likely to happen in the case of the cereals and cultivated crops, than in the plants which grow naturally in the soil.

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## CHAPTER V.

Mechanical treatment of soils. Deep plowing. Advantages of draining. Open drains. Plowing. Objects attained by plowing. Harrowing. Roller. Improvement of soils by mixture. Hoeing. Effects of hoeing.

§ 41. No doubt the proper mechanical treatment of soils is the most important part of husbandry and farming. By mechanical treatment we mean plowing, hoeing, harrowing, etc. If contrasted with the chemical treatment or with the use of manures, it will be evident that unless the mechanical treatment is right, much of the labor and expense of manuring will be lost. Probably there is no part of farming which is executed so poorly in North-Carolina as the mechanical treatment of soils. It fails to be effective for want of depth. It is true, we believe, that climate should be considered when the question of deep plowing is to be answered. That regard should be had to climate will appear from what has been said in the foregoing chapter with respect to the evaporation from freshly plowed surfaces. Under the more powerful influence of the sun's rays in the Southern States, the question may be raised whether the plowing which in New-York is called *deep plowing*, from 12 to 14 inches deep, might not result in two great a loss of water. But whether this question is answered in the affirmative or not, it will

be found true that deeper plowing than is usually practiced will be attended with greater success.

Preparatory to plowing stands *draining;* not always, but frequently. An important question to be answered is whether any given tract requires this preliminary treatment. Observation may readily return the reply. If water stands upon the surface only a few hours after a rain, it is probable draining will benefit the tract where it stands. If a bed of clay lies near the surface it is called for even if the top is sand. All swamps and bogs of course require it. In all the eastern counties there is a continuous bed of impervious brick clay, which often is not less than one foot from the surface, and its materials are often blended with the sand where it lies deper. This yellowish white clay will frequently be found cropping out in ravines where its position may be determined, and having determined its position, it will aid in solving the question of drainage. This bed of clay varies from four to seven feet thick, and is overlaid, and also underlaid with sand. These sand beds vary in thickness, and are always above the marls, unless we reckon among marls the recent shell bed of the coast. In drainage it is unnecessary to cut through the brick clay; it is sufficient to cut deeply into it, though the drainage will be more perfect if it is cut through. Another indication of the necessity of special drainage is furnished where springs issue near the surface. These are always thrown out by an impervious stratum. This impervious stratum may be sought for in ravines, or by boring with an auger of a suitable length; its depth beneath the surface may thereby be determined.

§ 42. Sandy clays which are sufficiently cohesive to be formed into balls by the hand when moistened, will require drainage. In drainage we not only have regard to surface water, to draw that off, but we must cut into the impervions stratum sufficiently deep to take out the water confined in its upper layers or beds. Otherwise the soil will rest on a bed always saturated with water, and always giving it off from the surface in vapor, and hence, will maintain a surface too cool for the growth of cotton or corn.

Another fact should be thought of and considered. Old soils become more compact and clayey by cultivation; and though in its new state crops were sure and certain, yet, in process of time, a change takes place. The greatest change is in the subsoil, which

becomes partially consolidated by the infiltration of the oxide of iron and carbonate of lime. Free percolation is stopped, and this partially indurated stratum should be cut through to restore a free passage of water. Breaking it up with a subsoil plow is not sufficient with many persons; this pan, as it is called, must not be cut. Experience, however, justifies it, and no harm ever follows from the practice.

§ 43. Drainage has been spoken of and recommended in the preceding chapter, but one or two advantages should be more distinctly stated. It is the openness which follows, and by which air penetrates freely the strata. The advantages, or it should be said the necessity for oxygen in the soil, is *absolute*, especially where organic matter exists, for we have shown that oxygen must change the vegetable fibre into *humates*, *geates*, and *crenic* and *apocrenic acids*, etc. All these changes are accompanied with the disengagement too of carbonic acid. If the vegetable fibre is confined in wet soils, it is converted into a peat only, in which state it is not fitted for vegetable assimilation. But in soils *air* must circulate; and when it is too close and compact, circulation can be effected only by drainage.

From the foregoing, it is plain drainage effects two objects:

§ 44. 1. It raises the temperature of the soil by sending the water in subterranean channels to distant parts. 2. It opens the texture of soil and permits the free passage of atmospheric air. Both the mechanical and chemical wants of vegetation are provided for by drainage. Among the advantages of draining one has already been fully stated; but still, let it not be forgotten that by it *seed time comes earlier*, where soil is drained, and it may and will happen that to an earlier planting a good crop is mainly due. A result of this kind, together with a larger crop for one or two seasons, will more than pay the expenditure incurred in the operation.

But when a general system of drainage for the country has been carried out, the general health of all its citizens will be secured. Stagnant pools will not exist; the water of wells will be improved and the climate will be measurably changed. Nothing can be more important than the sanitary effects of good drainage. The great source of intermittent fever is in stagnant waters. It is true we cannot prevent the freshets which give origin to miasmata, but

even here, drainage will have a salutary influence by carrying off at an earlier day the surplus waters.

The volume of this water is replaced by air. Hence it is plain that a very important change must necessarily take place. While soaked with water, which contains but little air, no chemical changes take place which produce fertilizing matter. The changes are preparatory only, but the peaty matter or peat itself, will remain peat, or become real coal forever. But draw off the water and replace it by atmospheric air with its active principle, *oxygen*, and a new order of things begins.

§ 45. Drainage is not neglected in North-Carolina, but its system is defective. Open drains are usually made; they effect the object less perfectly than *tile draining* when properly laid down. The former are obstructed by the growth of weeds, and the banks are in part closed to the free exit of water. They are also inconvenient, and hence, it is to be hoped, the time is not far distant when *tile* will be used. These remarks, however, are applicable to the uplands, the swamps must be drained by open ditches and canals.

§ 46. The operation next in importance to drainage is *plowing*. By the plow the surface is designed to be pulverized, should be pulverized, or else the operation is badly performed. The condition of the surface must be right, or else it will be imperfect, however skilful the holder of the plow may be. If wet, it should not be undertaken. This is a settled and well known point, but it is not always observed, for a large amount of pressing work in the spring may in one sense compel a farmer to plow before the soil is dried. Plowing is an old custom, and the experience of the world says that nations have prospered and communities prospered in the direct ratio that this operation approaches perfection. We throw out of mind all that is done in a new soil full of roots and stumps. Great crops of corn have been raised where the plow could not run. But every old country where roots, stumps and briars have been disposed of and the soil has found its level, there the plow must run. The importance of plowing is felt everywhere, is shown by the inventions of mechanics and farmers to perfect the machine and make an instrument which is adapted to all surfaces and depths to which the machine may be driven by cattle and the hand of man. The evil arising from plowing wet land is the lumpy condi-

tion of the furrow mass, and as these dry they become really indurated in the sun, and the consequence frequently is, that such a condition of the soil remains for one or two years.

Another important principle differing in kind from the foregoing is, that furrows should not run down hill; they should encircle the knowl or hill-side in order to divert streams from a direct descent, and thereby cut a side-hill ditch and finally lead to the formation of unseemly gullies. These, however, are not only unseemly, but monstrous evils, and especial care needs be taken in working the soils overlying the free-stones of this State. The first thing to be effected in plowing is good pulverization, the next is to open the soil to a sufficient depth for the roots to spread themselves, and an indirect benefit is secured when these two ends are accomplished, that of helping a crop through a drought without injury. The reader will understand the mode in which this comes to pass by applying the principles already stated.

Washing and the formation of gullies is also prevented in part by deep plowing. The subsoil plow is called into requisition to deepen furrows, but not to bring the broken substance to the surface. By deep plowing, especially if aided by the subsoil plow, the soil will absorb double the quantity of rain, and hence, diminish the amount which would otherwise escape in streams over the surface, and thereby carry off good soil, and tend to the formation of gullies.

Pulverization, an open, porous condition for roots to penetrate, depth for absorption of rain, together with a perfect mixture of the matters of the soil and fertilizers, are objects to be attained by plowing. These are all to be kept in view.

§ 47. The harrow and bush become necessary to break the lumps and form an even surface for the reception of seed.

The whole operation of seeding and providing for the germination of seed is completed by a heavy roller. This acts superficially, but fewer seed are lost by its employment, especially small seeds. Let a person step upon a celery bed and he will find that double the number of plants come up where the soil is pressed, than where its surface remains loose. It is to be regretted that the roller is not more frequently employed. It crushes clods which have escaped the harrow, and makes withal an even surface.

§ 48. The mechanical condition of a soil can rarely be ameliorated by mixture. Those which really require mixture are stiff clays and loose sands. If a mixture can be effected by the plow, it will no doubt pay. But it becomes quite questionable, whether a farmer can haul sand to mix with the clay, or clay to mix with the sand. The cost of hauling is too great. A gardner may make the necessary mixture. At any rate, before a farmer attempts to change a field of ten acres by mixing clay with sand, or the reverse, he had better count the cost beforehand. Now although a barren sand will not probably be benefitted by draining, yet the texture of the stiffest clays will be; and as clays are mixtures of silex and alumine, and as they are often, if not generally supplied with the alkalies and alkaline earths, the most direct as well as the cheapest mode to cure a clay of its stiffness, will be to remove the water by under drainage.

As it regards sand, it will be cheaper to employ calcareous fertilizers with forms of muck than to mix with it clay.

The theory of amendment by mixture is perfectly satisfactory; but in practice, it will be found a losing business, where either material has to be carted many rods.

§ 49. To recur once more to the subsoil plow in connexion with the clays too stiff to cultivate; it has been stated, that the subsoil plow should not be used until the land has been well drained. When considerable moisture exists in the clay, it unites and becomes solid and impervious, so that little benefit has been experienced in certain cases from subsoiling; but when the water has been drained off and the clays have become loose and porous, the masses raised by the plow still remain in this condition, or become still more porous, so that the beneficial effects of subsoiling a stiff under clay will not be secured till after the land has been well drained.

§ 50. It is scarcely necessary to speak of hoeing or the use of the cultivator. They are needful operations and no one omits them; but why hoe? is it simply to kill weeds? Hoeing kills weeds and pulverizes the soil, but it has an effect which is unseen except from its effects which are liable to be misinterpreted. The good effects of hoeing arise from the moist surface created, and which absorbs ammonia. That the beneficial effects do not all arise from the destruction of weeds and pulverization is evident from the fact that

the more frequently the surface is stirred and a moist surface exposed, the more vigorous the growth of the crop. The properties of ammonia remove all doubts respecting the effects of hoeing. Let the vapor of hartshorn in a receiver or tumbler be placed over a vessel of quicksilver, and then introduce a mass of moist soil, and see with how much rapidity the whole of the ammonia will be absorbed by the moist soil. Ammonia always exists in the atmosphere, and it is obtained in dry weather by exposing a fresh surface of soil to the atmosphere. Hoeing is a cheaper way of obtaining ammonia than buying it in guano; we get it in dry weather, and it is agreeable to the experience of all good observers, that hoeing in dry weather is followed with greater benefits than if the weather is wet. Gardens are hoed more frequently than field crops, though it may be supposed that the vigorous growth in the former is due to a rich soil. Still, the good effects of hoeing are too demonstrable to the eye to admit of doubt. Hoeing, however, is laborious, and too much time is consumed to admit of its repetition in field crops. To supply the place of the hoe the cultivator comes in, and no doubt its more frequent employment in dry weather, not simply to kill weeds and break sods, but to create a moist surface which will absorb ammonia, and which is now known to be so needful to all crops. Dry surface has little or no absorbative power as may be shown by introducing a ball of dry earth into a tumbler, or receiver of hartshorn in vapor.

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## CHAPTER VI.

Soil elements preserve the proportions very nearly as they exist in the parent rock. Weight of different kinds of soils. Most important elements of soil represented by fractions. Effects of small doses of fertilizer explained. Nature deals out her nutriment in atom doses, and so does the successful florist.

§ 51. It is well established by experiment and observation, that the soil contains, in its ordinary state, all the elements the vegeta-

ble kingdom needs. It is also known that all may be, and are probably derived from the solid rocks of the globe; and hence it will follow that the composition of the soil will not differ materially from the parent rock from which it is derived; and what is particularly worthy of note is, that the proportions of the elements will be found in the soil as they exist in the rock; and that where an element or compound is in excess in the rock, so it will be found in the soil, and where the proportion is small in the rock so it will necessarily be small in the soil. We propose in this chapter to state the quantities of elements in soils, and it will appear that though many important substances are extremely minute when put in a table of the common form used in chemical analysis; yet, if calculated therefrom in absolute quantities per acre, they are very large.

We have given the weight of cubic feet of sandy, clayey and peaty soils; these data will give the weight of a layer of soil of the area of an acre and one foot deep. A granite soil with its usual state of moisture weighs about 90 lbs to the square foot, and the superficial square feet of an acre weighs 3,920,000 pounds. If granite is composed of two-fifths quartz, two-fifths felspar and one-fifth mica, its composition will be represented by the following:

| | |
|---|---|
| Silex, | 74.84 |
| Alumina, | 12.80 |
| Potash, | 7.48 |
| Magnesia, | .99 |
| Lime, | .37 |
| Oxide of iron, | 1.93 |
| Oxide of manganese, | .12 |

It will be seen that in this and all other analyses of rocks and soils, that silex and alumina constitute by far the largest parts, while those elements which seem the most important to the vegetable occur, or are represented by fractions, and generally the fractions are much less than in the case selected. The potash given is the potash of the rock, and thus never occurs in the soil, and the fraction which should represent the potash of a granite soil will not exceed one-half of one per cent. in consequence of its solubility. But if it equals the lime, .37, the amount of potash in one hundred pounds of soil will be three-eighths of a pound. If the per centage

amounts to one-half of one per cent., there will be over twenty tons of the substance in the mass of soil, one foot thick and within the area of an acre. The small per centages, therefore, in an analysis, when calculated for a field, become large and important figures; and even where the Chemist makes his note as a trace, and which indicates its presence, without being able to weigh the element, it is still sufficient to meet the wants of vegetation. It is still greater than the farmer employs even when he uses gypsum, and much greater than when guano is employed. The interesting question then comes up, how can the great effects of guano be reconciled with the small quantity used? Two hundred pounds of guano to an acre, sown broadcast upon a wheat field, produces visible effects as far as the field can be seen when growing, and is known to double the crop. How can the great effects, then, be accounted for when the quantity is so small that it would be difficult to detect it in a pound of soil?

We may conceive it to be explained in this way: It is all dissolved and evenly distributed in the mass of soil, and is brought directly to the roots of the growing plant in the right condition to be taken up. It is not the absolute quantity called for by the crop, it is the state or condition of solution. Supposing four times as much used, and hence the solution would be four times as strong, would it produce quadruple effects? certainly not. Experience does not sanction the doctrine; instead of good effects, the crop would be hurt, or if taken up by the rootlets at all, it is too strong, and the probability is that much would not be taken up, as the strength or suspended particles of nutriment could not be received into the vegetable tissues at all.

We account then for the striking efforts of apparently homeopathic doses of fertilizers, on the ground of their solutions being adapted to the mouths of the spongioles through which the nutriment must enter the vegetable organism, and the adaptation in this state to the constitution of vegetables. All concentrated doses are rejected. All floriculturalists who produce beautiful flowers, employ agents extremely diluted. Others, who do not understand the business of feeding beautiful plants, attempt to cram them with too much and too rich solutions; the consequence is, the plants are killed outright, or else become yellow, their leaves drop, the whole plant indicates suffering.

It is highly probable too, that a farmer might produce results as beautiful as the florist, by pursuing like means; applying his fertilizers in a state of extreme dilution, in which case it is evenly distributed to roots and in a state in which it can be taken up. Facts constantly occurring in the analysis of soils, favor, and even sustain the doctrine. For how much soluble matter is there in one thousand grains of soil? It is possible to obtain one and one and a half per cent, consisting of 12 to 14 substances. Nature seems to dole out her treasures; instead of dealing liberally as befitting her, she gives atoms. There are practical principles in the facts developed. If soluble substances are employed, they too must be dealt out in atoms only. A few atoms at a time only are found in solution in the soil. The vegetable organism is only fitted to receive atoms; and in this we see adaptations which must be repeated. It is true, turkeys, swine and men may be crammed and fattened; but this system will not succeed in raising wheat, cotton or corn.

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## CHAPTER VII.

Fertilizers defined. Their necessity. Mechanical means of improvements of soil. Effects of lime. Growth is the result of change in the constitution of the fertilizers employed. Organs have each their own special influence upon the fertilizing matter they receive. Provisions for sustaining vegetable life. A system of adaptive husbandry. Instances cited. Adaptation of a crop to the soil. What fertilizers will ripen a crop at the right time. The source of fertilizers. Green crops. Peat. Advantages of a green crop. Marine plants. Straw. Losses of farm yard manure. Peat, how prepared for use. Composts. Fertilizers of animal origin. Solids and fluids.

§ 52. A Fertilizer is a substance which promotes the growth of vegetables. In this definition is included water, and a great variety of bodies which would scarcely be ranked under the name of manures. The latter term is generally applied to the excrements of animals, and yet, it has a wide signification, so that when we

have really determined the number of bodies which may be classified under it, we find that its meaning is as extensive as that of fertilizer.

§ 53. The necessity which has given rise to the use of this class of bodies, is the excessive taxation of the natural resources of soil for the support of much greater crops than the soil would spontaneously produce, and this taxation being prolonged century in, and century out, the necessity now for resorting to their use and hereafter, has become a fixed institution, established in absolute dominion upon the money and labor of all who have anything to do in agriculture in earnest. The improvement of the soil by mechanical means extends farther than the simple movement of it in a certain way, turning it over with the plow, breaking up the compact matter at the bottom of a furrow, exposing fresh surfaces with the hoe or cultivator; for in all these there are excited chemical actions, whereby combinations promoting growth take place. So also the employment of chemical bodies do not end strictly in chemical changes; mechanical ones result from chemical actions. Witness the effect of quick lime upon a clay soil; it becomes porous and light, even more so than by the use of the plow and hoe; besides, it is a *permanent* change in texture as well as composition. From the foregoing facts, it will be seen how one system of improvement connects itself with another, and that the institution of one system of means sets in motion those which seemingly belong to an opposite kind. We repeat that mechanical agencies result in chemical, and chemical ones result also in mechanical. All means, therefore, for improving the soil belong to double systems, excepting those instances where a fertilizer is selected with reference to a single result, as is often the case in most of the soils; as in sulphate of ammonia, nitrate of potash, or phosphate of lime.

But still, fertilizers improve soils by chemical agencies, and we shall now consider them in this range of their functions, leaving out of view any mechanical results they may produce.

§ 54. All applications of substances designed to promote growth do not always act by the results of change in themselves, nor by inducing chemical changes in others prior to their introduction into the organism of the plant. But by far the greater number of fertilizers undergo a change somewhere before they are assimilated,

or become incorporated into the vegetable body. We cannot think of any thing, how much alike it seems to the constitution of organized matter, which must not be changed in its chemical constitution before it finds its destined position in the vegetable structure. Water, it is true, acting as the vehicle by which food is conveyed inward, passes through and out again by respiratory pores and undergoes no change; but, what it transmits, must be changed. The actions of organs have much that is special; each organ its own wants, and its own apparatus to supply them. The husk of a kernel of grain demands its supply, and though it gets a supply from the common circulating store, yet its organization elaborates from that supply, something quite different from that of the kernel, leaf or stalk. The changes indicated are regarded as chemical, with what, and how much right, we cannot decide. There is a vitality in each and every part and organ; how much is to be attributed to this principle has never been agreed upon; but it is supposed by some that this principle is a force or power controlling the movements in question; yet, the changes in the substance are like unto chemical products taking place independently of this subtle force called *vital*. But the foregoing is a departure from the track or line in which we designed to move.

§ 55. But before we speak of the fertilizers we may profitably look at or consider the natural provisions for sustaining vegetable life when left to the workings of its own unaided machinery. The machinery consists of organs for support and reception, discharge and growth. The first are the roots, which consist of a tapering stem which sends off threads terminating in a congeries of exceedingly minute orifices, which are called *spongioles*, whose office is to obtain, and we might perhaps say, *select* nutriment. The second class of organs are the leaves. They exhale water, in vapor of course, from pores which are mainly located upon the under side. The water is pure, though it has been the carrier of food, as it is called, from which has been manufactured salts, sugar, starch, extract, gum, woody fibre, etc. The superfluous water escapes from the surface of leaves. But leaves, besides performing the office of exhalation, perform that of reception, or of absorption. This office, however, appears to be an important one in the clover and allied plants; while in the cereals, it is much less so. The movement of water (and when impregnated with foreign matter, is

called sap,) is upward and outward, so as to distribute it to the new growing organs. It passes into cells in its upward progress, where it is changed or assimilated, and becomes by its passage through them, perhaps by the action of its walls, *vegetalised*, if we may coin a word answering to *animalised*. There is motion in all directions, but the currents tend upward and outward, so as to reach the extreme bud and leaf. This is a necessary result, because the bud, leaf, and extreme of the branches seem to be the source of the force by which circulation is carried on. In the workings of this imperfectly described machinery, which may be regarded as belonging to a tree, we find organs which are but temporary in their office, and which therefore require periodical renewals. These are the leaves, fruit and bark. The permanent organs are the trunk with its limbs, and the roots. The growth is both aerial and sub-terrestial. The latter keeps pace with the former; the roots spread equally with the branches, and that the roots may be fed they penetrate outwardly into new feeding grounds, which like the leaves, bark and fruit in falling after decay, help supply the necessary nutriment. They re-supply in part, and once again traverse the organism.

§ 56. Time, also, is not to be lost sight of in the range of enquiries relative to fertilizers. It may be, and is, of great importance to get an early and good stand; the result of the crop may turn upon this one point. Hence, what treatment, what fertilizer will best fulfil the end sought; for instance, in a crop of tobacco or cotton? What is wanted is an early, or indeed an immediate effect; one which will not retard the germination of the seed; but which will act *gently* upon the infant plant. The dose, too, is an important consideration; a tea-spoonful of broth is not too much for the infant, while a table-spoonful, which an adult stomach would manage, would be too much for the former.

There is another enquiry in range of the specialities we are considering. What fertilizer will ripen a crop at the best time and manner? This may not have been thought of so frequently as some other questions; but the tobacco grower's attention has been turned to it. This crop must ripen evenly before frost; and as it is a *leaf ripening*, not a seed, an organ which has no connexion with the organs by which the plant is propagated, but is supplied ... h cellular tissue, which may grow and develope itself indefinitely,

and which, under the influence of abundance of nutriment, will keep green; this organ, the leaf, may not ripen at the right time, and may ripen quite irregularly and the crop be half spoiled. The problem, then, for the tobacco grower to solve, is, what fertilizer will spend its powers and exert its properties to the best advantage in order that the leaf shall not grow too large, but expend or exhaust its power before frost, and thereby promote its ripening at the right time; for, as long as the leaf is encouraged to grow by the fertilizer employed, it will not stop to ripen. The leaf is under a different law from the organs which propagate the species, though even these may not put forth their powers when the woody system is over stimulated with nutriment.

A system of husbandry which is now called for is *adaptive*, or to use another term of like import, should be as far as possible *special;* by which we mean, the use of those means of improvement which are adapted to the *soil crop.* It is now proved by experiment, that phosphatic fertilizers are better adapted to the growth of turnips than ammoniacal ones, and that a combination of ammoniacal and phosphatic are best suited to wheat. These are instances of adaptive husbandry. How many such instances will be established by experiment and observation we cannot tell. But their discovery is in the right direction; it is a progression towards perfection. So also as to the mode of application; abundant experience and observation point to the fact, that surface application is the true mode for grass lands. But it may not be the best for corn lands; it may not supercede a more immediate application of certain fertilizers to the hill of corn.

So again, the adaptation of a crop to the soil and to the condition of any particular kind, is an established principle. Clayey lands are better for wheat than sandy, and sandy soils grow rye better than they do wheat. But observations in this direction are older than those which are established relative to the special use of fertilizers. The enquiry is and has been in the mind of every farmer, what is this piece of land adapted to? What kind of crop will be the most profitable? and the consequence of this kind of enquiry has been to establish many important practical results which are now acted upon every day by our best farmers. This field of improvement comes first in the order of time; and from the nature

of things, has made greater progress than that which comes from the special use and adaptations of fertilizers.

§ 57. Fertilizers belong to the three kingdoms, and it will promote a systematic view of them by adopting a classification corresponding to their origin or source.

The most striking difference in these classes is their bulk and the quantity which is to be applied. Those fertilizers which are derived from the vegetable kingdom are bulky; and hence, one important result is secured, which cannot be obtained from the others, especially the mineral kingdom; they lighten the soil and make it more open than the other two; a result which is due from bulk alone, while, if porosity results from mineral fertilizers, it is in consequence of chemical changes in the soil. Mineral manures are more special than vegetable or animal; which arises from the fact that they are less complex in their composition, or consist of two or three elements only. We might have made another class, inasmuch as some of the most favorite compounds are composed of substances derived from the three kingdoms. These are composts, and it might at first sight be inferred that *guano* ought to be classified in both the mineral and animal kingdoms; but it is plain that what is strictly mineral in it is secondarily derived from the animal kingdom only; as it consists of the excrements of birds, who have subsisted mainly upon fish or other animal bodies.

§ 58. Vegetable fertilizers do not furnish exclusively vegetable matter, they also yield up mineral matter, which has already been mentioned under the name *inorganic.* It is that which has been taken up and fulfilled its functions in the vegetable organism, and now, after its death, it is again seperated by a series of chemical actions, and restored again to the soil. It is probably the best part of it, and sooner or more easily soluble, or more quickly prepared for its reception into the vegetable organism than the unchanged elements of soil.

§ 59. Vegetable fertilizers are matters which have decomposed; their particles separated as well mechanically as chemically; in fine, which have passed through a series of changes which have resulted in the formation of a class of new bodies. The vegetable loses its green, and is blackened, as if charred, but at the same time is softened and becomes pulpy; the fibrous structure disappears and the organization is broken up. It has become subject to

chemical laws. The common term is *rotten* or rotted. All vegetable matters pass through the same changes, whether matured wood, twigs or leaves. Matured wood requires more time, but ultimately it will become a mixed fertilizer, and have a value proportioned to the kind of inorganic matter combined with its quantity; for observation and experiment proves that the pines, poplars and willows have less mineral matters than oak, hickory or birch; and certain parts have more than others. The bark of the oak is richer in lime than the wood; the twigs and leaves are richer in phosphates than the wood, and the fruits are worth more for fertilizers than other parts, because they contain more potash and phosphates combined. One thousand pounds of the willow wood will enrich the soil four and a half per cent., while one thousand pounds of dry leaves will enrich it at the rate of eighty-two per cent. Leaves then would bear hauling much farther than the saw dust of willows or pines; hence, it will be perceived that leaves must produce a much greater effect; they are richer in the money elements.

Fertilizers belonging to the vegetable kingdom are used in a green or in a decomposing state, as in green crops, plowed under and in the condition of peat, or peaty matter formed in bogs, and in a state of partial decay.

Green crops are fertilizers of the first order, being decomposable speedily in consequence of the full charge of sap which they contain when plowed under the sod. They change into a light black mould and assume the condition of a compost heap. A crop is selected for this purpose which grows rapidly, has extensive roots, and is supposed to obtain its stock of materials in part from the atmosphere. This last is considered a clear gain. The extended roots concentrate the mineral matter in the plant, and if its roots run deep, bring up fertilizers beyond the reach of the wheat plant. At any rate, whatever the green crop contains is laid down in a layer some four or five inches beneath the surface, and is really a magazine of food.

The red clover and buckwheat are employed most frequently in the northern and middle States, while the pea is best adapted to the latitude and climate of North and South-Carolina. But all that part of North-Carolina which lies north of the Central Railroad, may sow clover instead of the pea. But the pea is a richer plant,

especially if the plant is mature, and its pods filled with fruit. The pea has long roots; we have found them twelve feet long. Green manuring is not confined to the plants named; all the clover class, as lupin, lucern, etc., borage, turnips, and wild mustard are sown in Europe for the same purpose.

§ 60. The advantages accruing from green crops are numerous, but they are both mechanical and chemical; the *development* of ammonia, nitric and carbonic acid within the soil and which therefore are in the best condition to be absorbed by it, belong to the latter. It is maintained that a green crop plowed in enriches the soil as much as the droppings of cattle from three times the quantity of green food consigned to the soil by the plow. Another advantage claimed is, that about three-fourths of the whole organic matter is derived from the atmosphere. This is the most likely to be true in the clover and bean family.

Those who reside near the sea may obtain sea-weed, and plow it in, in the same condition that it is cast upon the shore. Sea-weeds decompose readily; they yield both organic and saline matter, and are nearly equal, for potatoes, to barnyard manure. Sea-weeds are a specific fertilizer for asparagus, a sea-shore plant. The coast of North-Carolina, however, does not abound so much in this class of fertilizers, as the northern rocky shores of the Atlantic. The foregoing fertilizers are employed in their wet state. The following are spread upon the ground dry.

§ 61. Straw of all kinds are used as fertilizers. In the condition of straw or hay, which is a plant dried in the sun, the decomposition is comparatively slow, even if buried in the soil. Mixed with animal matter in heaps, its change is rapid; fermentation is induced which soon reduces the mass to a bulky consistence, or the fibre of the straw is separated or broken, and admits, thereby, of a ready incorporation with the soil.

Fertilizers undergoing a series of changes in the yards where they are formed are subject to a considerable loss of weight. The figures given by Johnson are the following. A recent mixture

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| weighs, for example, from | 46 to 50 cwt. |
| After 6 weeks, weighs | 40 to 44 " |
| After 8 weeks, weighs | 38 to 40 " |
| After when half rotten, weighs | 30 to 35 " |
| And when fully rotten, weighs | 20 to 25 " |

A loss of more than one-half of its weight during the time required to make what is called *short manure.* But it is not a loss of one-half its value. It may be infered that the principal loss in weight is water, though ammonia and carbonic acid also escape. But an informed farmer would stop the loss of valuable parts by the use of absorbents, as plaster, weak solution of sulphate of iron, sprinkled over the heap or mass, while fermenting. By these means, if the loss in weight was not entirely prevented, it would greatly diminish that which is regarded as valuable and be confined to the watery parts.

Covering the dry manure in the soil answers the same purpose. Among the dry materials generally discarded by our farmers is *saw dust.* It lies in great heaps around the sites of old saw mills, and has never, in this State, been employed as a manure. It is true that it generally consists of pine, still, on sandy lands, applied in small and repeated doses, it will supply organic matter and prepare the way for a satisfactory use of marl. One hundred loads to the acre is a suitable quantity. This should be spread and ploughed in.

§ 62. The seeds of all plants are richer fertilizers than the stems or leaves. Cotton seed is in great repute, indeed all that furnish oils seem to be well adapted to promote vegetation.

Rape seed (Brassica napus) is equal to cotton seed, but is too valuable for its oil to be employed before expression. The cake which remains is still valuable.

§ 63. Peat is one of the most common materials which has been employed as a fertilizer, and has received the same sanction of those who have used it, and as it is widely distributed it is necessary to notice it in this connexion. It may be regarded as the basis of all composts. It may be employed by itself, provided it is brought by sufficient exposure to the air and moisture to pass into a pulverulent state when mixed with the soil. If lumps of peat, which have dried in the air, are buried in the soil, they continue in the condition of lumps as a nuisance for two or three years, but if kept moist in a heap, and a species of fermentation is excited, it then pulverises and mixes readily with the soil.

Peat is best prepared for crops by composting it with other substances. Johnson gives the following formula as the best, all

things considered, especially with reference to the cost of materials, and the effects which are produced:

| | |
|---|---|
| Saw dust or earthy peat, (muck,) | 40 bushels. |
| Coal tar, | 20 gallons. |
| Bone dust, | 7 bushels. |
| Sulphate of soda, (glaubers salts,) | 1 cwt. |
| Sulphate of magnesia, (ep. salts,) | 1½ cwt. |
| Common salt, | 1½ cwt. |
| Quick lime, | 20 bushels. |

"These materials are mixed and put into a heap and allowed to ferment three weeks; then turned and allowed again to ferment, when the compost is ready for use.

"This compound is compared with guano, both as a fertilizer for hay and turnips.

"On hay, per imperial acre:

| | PRODUCE. | COST. |
|---|---|---|
| Nothing, | 416 stones. | |
| Guano, 3 cwt., | 752 " | $7 50 |
| Compost, 40 bushels, | 761 " | 5 00 |

"On turnips:

| | PRODUCE. | COST. |
|---|---|---|
| Farm yard manure, 28 yards, | 26 tons. | |
| Guano, 5 cwt., | 18 " | $12 50 |
| Compost, 64 bushels, | 29 " | 7 75 |

According to the foregoing experiments the compost seems to be better than guano."

But Johnson remarks that the experiments need repeating, and yet from the nature of the compost there is nothing improbable in the results. It will be observed that the compost contains coal tar, a substance which, *a priori*, we should be very likely to place any where else than in a list with fertilizers, yet experience proves its value.

A combination of one hundred parts of plaster, and from one to three parts of coal tar, well mixed in a mortar, is valuable in agriculture. For certain purposes olive oil is added, as when the mixture is designed for application to putrid sores, etc. This is principally used, but without the olive oil, in place of chloride of

lime to disinfect sinks, privies, etc. It purifies water in a short time.

But it is also valuable in agriculture, one-half a pound of the powder dissolved in 5 or 6 gallons of water and sprinkled on the litter of a stable will deprive a cubic yard of manure of all odor, and prevent the loss of fertilizing matter.

Coal tar has also been applied, *per se*, to wheat stubble for the benefit of a root crop which was to succeed.

The use of coal tar is mentioned in this place as in many of the towns of North-Carolina it can be obtained at the gas works. It is now wasted. It is expected, also, that the kerosine oil works, which are about to be established upon Deep river, will furnish large quantities of coal tar for market.

§ 64. But to return to the consideration of peat and muck. Many questions have been raised with respect to their use, which are really superfluous; as in what kinds of soils do they produce the best results, etc. Now, this substance, if properly prepared, acts beneficially on all kinds of soils. It may be in a condition to benefit no soil; and hence, prejudices will be raised, when its failure is our own fault. But questions respecting *the best mode of preparing it for use*, are highly important.

There are many modes of composting, and undoubtedly some formula prescribing the ingredients should be adopted; and in constructing a formula, regard must be had, both to the crop it is intended for, and the condition of the soil to which it is to be applied.

In practice, muck or peat which by itself is scarcely soluble, requires an *alkali* to effect a solution of it at least.

Mr. Dana, in his Muck Manual, gives a good formula which can be followed by any person who is inclined to try it. It is composed of the following proportions:

| | |
|---|---|
| Peat, | 50 lbs. |
| Salt, | ½ bushel. |
| Ashes, | 1 do. |
| Water, | 100 gallons. |

The ashes and peat are well mixed, adding a little water to moisten the materials. This mixture lies a week, when the dissolved salt or brine is to be added and well stirred in a hogshead.

It requires stirring for a week, when it is fit for use. The brown liquid which floats above the peat, contains the whole organic matter in the salts. This is to be applied to the land it is designed for, in solution. In the course of four or five weeks, however, another substance is formed, sulphuretted hydrogen, which is injurious to vegetation. But in the mean time, repeated additions of water will furnish more soluble matter from the peat. A decided benefit is seen upon corn, onions, grass, barley, etc. A compost of these materials applied dry will be attained with less trouble, and though its effects may not be exhibited so soon, yet they will last longer. In the present state of our knowledge respecting the powers of the roots of vegetables to select or obtain nutriment, the necessity of obtaining a soluble condition of peat before its application, is not well settled; for it seems that the roots do act upon insoluble matters, and appropriate them to the use of the plant. By this phraseology, it is not meant that roots do take up insoluble material, but that they have a power of imparting solubility which water by its own action has not.

§ 65. *Fertilizers of Animal Origin.*—It will be superfluous to enumerate all the kinds which are referred to the animal kingdom. It is sufficient to observe that everything has been or may be employed for manures which has lived. All parts, all organs, hair, wool, skin, flesh and bone, help make up the list. To the foregoing we may add the animal liquids, blood, and the excrements both solid and liquid. As in the vegetable kingdom, they possess different values.

A knowledge of their composition furnishes a reason why they are so, as well as how they act.

Bone is composed of:

| | |
|---|---|
| Phosphate of lime, | 55.50 |
| " Magnesia, | 2.00 |
| Soda and common salt, | 2.50 |
| Carbonate of lime, | 3.25 |
| Fluoride of calcium, | 3.00 |
| Gelatine, | 33.25 |
| | 100.00 |

In adding dry bone pulverized there is added thirty-three per cent. of organic matter in gelatine.

Bones are employed in a dry state after being ground or crushed. They of course act slowly in this condition, but with excellent results. The most popular mode of employing bone, however, is as a super-phosphate, as it is called. This substance is prepared by mixing one half of its weight or its whole weight, which is better, with sulphuric acid, (oil of vitriol,) previously diluted with three times its bulk of water. The materials require repeated stirring. When the solution is effected, a pasty substance is obtained. Two modes of applying it are recommended. The first in substance, in the condition of a powder. This is obtained by mixing with charcoal powder, dry peat, saw-dust or a fine vegetable soil. If it is wished to drill in this fertilizer with the seed for a crop, as wheat, the powdered state as above may be resorted to, or if it is designed to use a solution, it is necessary to add forty or fifty times its quantity of water, when it may be applied to the crop with a water cart. The latter mode brings out results much more speedily, and as farmers are anxious to see immediate effects, the latter may afford more encouragement to use those fertilizers which belong to the first class.

§ 66. The comparative results as determined by experiments of the two forms of bones, the crushed and dissolved, should be given in this connexion. Thus, while 16 bushels of crushed bones gave ten tons and three hundred pounds per acre, two bushels of super-phosphate gave nine tons and twelve hundred pounds; the latter approximating very closely upon the former. But this statement taken literally, does not reveal to us the state of the case, for the latter has cost something for its preparation, but the difference in the long run will be found to be much less, inasmuch as the powdered preparation will continue to fertilize the soil for the next 10 years without additional expense; and yet the following practice we would recommend, viz: for all cultivated crops, as turnips, corn, oats, etc., to use the super-phosphate on the score of speedy action and immediate results; for long continued use, as for pastures and hay, the ground bones. The powder will be slowly dissolved by the aid of carbonic acid and furnish thereby a constant supply of food for years in succession. So also, as a fertilizer for vines and fruit trees, the bone in substance answers a better pur-

pose than the super-phosphate. It is no object to over manure a vine or tree; what is wanted is a steady and constant supply. When a great growth of vine and limbs is obtained by great doses of fertilizers, the wood is not perfected, and the tendency will be to develope imperfectly consolidated or unripe wood rather than fruit; there will be an over-burthen of the latter. Even uncrushed bones buried among the roots of a vine produce the best of results. In that way, the bones are, as it were, penetrated by thousands of spongioles, which, by a power not well understood, supply from these comparatively insoluble bodies, all the nutriment they require of this kind, for heavy crops.

The experiments of WOHLER show that bones are soluble in water without the aid of carbonic acid. Water which has been filtered through a mass of bones, has always contained phosphates in solution. But it appears that the quantity dissolved depends partly upon the stage of putrefaction which they have reached; and hence, it is inferred that fresh bones kept wet will furnish this important fertilizer in a mode cheaper than that which is usually pursued.

§ 67. Horn (horn core) is composed of:

| | |
|---|---|
| Water, ........................................ | 10.31 |
| Phosphates of lime and magnesia, .............. | 46.14 |
| Carbonate of lime, ............................ | 7.71 |
| Gelatine (organic matter) ..................... | 35.84 |
| | 100.00 |

§ 68. Liquid excrements, as the urine of different animals, instead of being preserved in its liquid state, have been of late mixed with a sufficient quantity of gypsum to fix the volatile compounds, as the ammonia, and then dried to a powder; in this state it is applied to land. But it is doubtful if it has an advantage over the mixture composed of peat. Let every one consult his feelings in regard to the preparation of these bodies, especially where apparatus is not at hand, and he will readily understand why it is that the preparation and even preservation of many valuable substances is neglected; for much care and work is involved in the process when evaporation and preparation of superphosphates are talked about. But when preservation and preparations are sim-

plified, it is possible to persuade farmers to undertake it. It is not so much for want of knowledge that so much is neglected; it is because the work is presented in a shape too complicated, or requiring too much attention and labor. Guano, with all its expense, has taken everywhere, because it is ready to apply. If farmers had to cook it before it could be used, very little would have been used in North-Carolina.

§ 69. For these reasons it is believed that very few will resort to the use of tanks and distribution carts for the preservation and distribution of the liquid excrements of men and cattle. A muck or peat yard with a depression in the middle, which may be made the receptacle of offal, blood, urine, etc., will be found the most eligible mode of preserving these bodies. It is known that every thing is to go there, and all that will be required to preserve the volatile matters and absorb offensive gases, will be to use plaster and peat intermixed with a small quantity of coal tar, which can now be procured in almost every village of the State. These imperfect compost beds may be turned over with the fork from time to time in order to secure a perfect mixture. It should be spread broadcast, and the harrow used to mix it with upper soil.

§ 70. For the preparation of the fluid substances of animals, a compost with peat is probably the best which can be devised. Blood and fluid excrements mixed with charcoal or peat, the latter of which is the cheapest and most easily prepared, form with little labor and expense an excellent compost. Indeed the basis should be kept in heaps for the reception of fluid refuse matter; even the soapsuds of the wash room, which are generally wasted, should find a repository there. But let the small farmer enumerate the animal substances which might be saved in the course of a year. The blood, hair, wool, bristles, feathers, skin, old leather, woolen rags, fragments of bones, to which we may add entire carcasses of dead animals, even cats and dogs, will form a formidable mass when deposited together in the farmyard. These, when moistened or wet in a heap with ammoniated compounds, or even water, will soften, undergo a partial fermentation, and in time become as valuable as guano. The absorbant power of peat and charcoal will fix all the valuable gases.

The preservation of the foregoing substances require no cash, and very little time, and there is no necessity of attempting the

regulation of the quantity by weight or measure. Woolen rags may be deposited among the roots of vines or fruit trees; hair, bristles, old shoes and leather, etc., may have the same destination. One ton of hair, bristles and wool are worth as much as four or five tons of blood. The dry materials enumerated are fitted to those crops which are to be sustained for several years in succession, as meadow land and pasturage, while the fluid and easily decomposed kinds are better suited to the annual hoed crops. In this distribution we obtain more speedily their money value. Nitrogen is supposed to be the most important element of animal bodies. Thus dry blood contains 15.50 per cent.; dry skin, hair and horns, from 16 to 17.50 per cent. of nitrogen. Still, all these substances are rich in phosphates, and hence, their value is due in part to the latter.

To the planter, the importance of providing for the preparation or preservation of night soil, presents itself in a strong light; especially, if we can confide in the conclusions of Bousingault. According to this distinguished farmer and chemist, the liquid and solid excrements of an adult individual amount on the average to 1½ pounds daily, and that they contain 3 per cent of nitrogen. According to this calculation, they will amount in a year to 547 pounds, containing 16.41 pounds nitrogen; a quantity sufficient to yield the nitrogen of 800 pounds of wheat, or of 900 pounds barley. The quantity is more than sufficient to fertilize an acre of land. From the foregoing it is not difficult to form an estimate of what is lost upon plantations stocked with one hundred, or any given number of laborers; or to place it in another point of view, how much might be gained by the adoption of means which shall enforce the preservation of excrements, both liquid and solid.

## CHAPTER VIII.

Solid excrements. Guano. Composition and comparative value. Discrepancies stated.

§ 71. The solid excrements of animals form a well known class of fertilizing bodies of great value. Their value depends upon the food upon which the animals are supported. It may consist of matters little better than ground hay intermixed with small portions of mucus; or if fed upon corn, it is richly charged with ammonia, or perhaps still richer, if fed upon fish and animal substances. The kinds receive their designation according to their origin. Night soil, human excrement, which when dried with gypsum or lime, is sold under the name of *poudrette.* The former, in consequence of its richness, loses more of its value by exposure to the atmosphere, than any other kind. Hence arises the necessity of mixing it with absorbants, such as plaster, charcoal, peat, sawdust, etc. To these may be added the sulphuric acid or muriatic; both form with ammonia a valuable fertilizer. Muriatic acid may be sprinkled over foecal matters in the vault from a copper watering vessel. The acid should be diluted with two and a half times its bulk of water.

The products of the horse, cow and hog should be mixed together, as in that case the properties which are wanting in one are supplied by the other. Fermentation, resulting in a prepared state for use, will be secured more safely than when they are used alone. Those of the horse, it is well known, if packed into heaps, heats and is nearly destroyed. That of hogs fattening upon grain is probably richer than any other, but is far less liable to heat than the former. It is accused of imparting an unpleasant taste to roots when freely used, in consequence of containing an unexamined volatile substance.

§ 72. The excrement of birds is richer in fertilizing matter than quadrupeds, in consequence of mixture. The urate which exists in the urine of the latter, passes off with the foecal in the former. That of pigeons is in repute in Flanders, Spain and other countries in Europe. In some parts of Spain it is sold for fourpence a pound, and is used for melons, tomatoes and flower roots.

Its valuable properties are no doubt due to the grains upon which the birds feed. In Flanders the manure of one hundred birds is worth twenty shillings a year for agricultural purposes.

Equally valuable are the same products from the domestic fowl, geese and ducks, when fed upon corn. When the domestic fowl is lodged in a suitable shed, the free use of gypsum upon the floor is indispensable to the preservation of the volatile parts. It is necessary to use it with the same care as is observed in the use of all compounds which contain the elements of ammonia.

§ 73. Of the solid animal fertilizers, the most celebrated of this class is *Guano*, now generally used and is by some regarded as almost indispensable for the successful cultivation of wheat and tobacco, etc.

This substance consists of the excrements of birds, (sea fowl,) which feed mostly on fish or animal matter. The accumulation and composition is to be attributed to the dryness of the atmosphere. There are two varieties in market, the South-American from the coast of Peru, and the Mexican from the Gulf. The former is from a rainless *district*, and hence retains its soluble matter; the latter is from a district subject to rains, and hence its ammonia salts and other soluble matters are diminished to a minimum quantity. A little reflection will enable a person of information to understand their relative values, especially when it is known that the latter frequently contains from 60 to 80 per cent. of bone earth, and the former 50 per cent. of soluble matters, and rich in ammoniacal salts, and only about 23 to 25 per cent. of phosphates or bone earth. In accounting, however, for the effects of guano, we should not lose sight of their complex composition. This fact is brought out in the following analysis:

| | VOELKER. |
|---|---|
| Urate of ammonia, | 3.24 |
| Oxalate of ammonia, | 13.35 |
| " Lime, | 16.36 |
| Phosphate of ammonia, | 6.45 |
| " Lime, | 9.94 |
| " Ammonia and magnesia, | 4.19 |
| " Soda, | 5.29 |
| Muriate of soda, | 0.10 |
| Sulphate of soda, | 1.19 |
| " Potash, | 4.22 |

| | |
|---|---|
| Muriate of ammonia, | 6.50 |
| Water and organic matter, | 5.90 |
| Clay and sand, | 28.31 |

This elaborate analysis is selected for the purpose of showing the complexity of composition of guano. The most valuable parts of it, it will be seen, are the ammoniacal salts and phosphatic salts. In some varieties the guano is weakened by sand and clay; it is often much less, rarely more, unless adulterated. Potash is usually regarded as existing in too small proportions to effect its value, yet it is found as a salt in this case to be larger than usual; the per centage rarely exceeding one per cent. It may be expected, therefore, that this deficiency may be observed in the course of a few years of use.

§ 74. The length of time during which guano acts is estimated variously by observers, though all agree that the guano of the rainless districts have a shorter life than those which are preserved upon a rainy coast. The reason is obvious. In this climate the former are expended in two years; the latter, as they resemble bone earth, last longer,—at least twice as long.

It must be admitted that guano, in this country, has laid agriculture under immense obligations. It has encouraged, or, indeed, inaugurated a new system, and has given that impetus to it which will never die out.

The advantages of guano in the Southern States are numerous. By its use old fields are brought into bearing immediately, and bear at once money making crops. Several years are required to resuscitate an old field in the ordinary mode of procedure. The result, then, is the saving of time. On cotton and tobacco its influence is felt strongly in securing early a good stand. Its influence is continued down to the right period for ripening, and no doubt in those cases where the proper quantity is used it ceases to grow, and the process proceeds regularly, and thereby secures uniformity; a point of the greatest importance where a high priced tobacco is the object.

The quantity of guano per acre, which is useful, seems to be tolerably well determined. Very few use more than two hundred pounds to the acre. Curious, as well as instructive experiments

are given in Johnson's elements of agriculture of the effects of *quantity* on a crop. Thus:

| QUANTITY OF GUANO. | EFFECT ON THE TURNIP CROP. | ON THE AFTER CROP OF WHEAT. |
|---|---|---|
| 4 cwt. to the acre, (Scotch.) | 18 tons of good turnips. | Good wheat. |
| 8 cwt. to the acre. | 14 tons very indifferent. | Inferior. |
| 16 cwt. to the acre. | Looked, when young, wonderfully well, but there was *little bulb* in the end, produce 10 tons. | Stuble black, grain dark, and not larger than small rice. |

Guano is accused of acting injuriously when its use is protracted. The probable influence of guano, when used for several years on the same area, is to cause an exhaustion of those elements in the soil which the guano cannot supply. Potash is probably so much diminished that it ceases to furnish it to the crops. However this may be, it is evident that its use increases so largely the quantity or weight that to supply any element from the soil alone would diminish the stock or magazine in a greater ratio, and hence more speedily than ordinary crops. Hence, as the supply is derived originally from the rocks, and never can accummulate under these circumstances, though every year adds its atoms to the soil, yet it is used faster by far than it is produced; the consequence is, the stock will be too much diminished to supply the wants after an uncertain period, and the soil will actually become poor in one or more elements necessary to the cultivated plant.

If potash is deficient in a soil, and is the result of the excessive use of guano, the addition of leached ashes will supply the deficiency; but a mixture of well pulverized peat and ashes with guano will best supply the deficiences of this fertilizer. It is doubtful whether the use of guano ought not to be *intermittent.* As we have said, it saves time in resuscitating old fields. If, after one or two years, guano is dismissed, and the fertility is kept up afterwards by vegetable and mineral substances composted together, the evil of exhaustion will be averted.

§ 75. In consequence of the high price of guano, an article of an inferior value is often brought to market, or else it is adulterated. Chemical changes also affect its value. It is not easy to form a judgment by occular inspection. Those which are *brown* have undergone those changes which approximate a decomposition, which

discharges a large proportion of its ammonia. Hence, the lighter the color the less change it has undergone, and therefore the better.

A strong odor of ammonia is a good indication; if not free, a trial may be made by mixing a spoonful of it with air-slacked lime in a glass; ammonia fumes ought to be exhaled if good. Too much water is indicated by its mechanical condition. Fifty-five dollars per ton for water is a poor investment. Guano then should be dry. If much sand is intermixed it may be detected by mixing it with water in a tumbler, giving a little time for subsidence, pour off the top, repeat the operation a few times, and the quantity of sand will remain at the bottom of the tumbler. There is another experiment which it is easy to perform for the purpose of determining the quantity of sand, and if weighed, the result may be quite accurate. Heat the weighed quantity to redness, when the volatile matters, ammonia and others of that nature, will be consumed or dissipated. Dissolve the remainder in dilute muriatic acid of the shops by applying a moderate heat. The remainder will be sand or other useless earth. Elaborate analyses are too difficult and expensive to be undertaken for a moderate quantity of guano, but the foregoing may be resorted to and ought to be; for they may account for a failure, or explain more satisfactorily the results upon the crop, whether remarkably good, indifferent or bad. Much, however, must be trusted to the character of the merchant.

§ 76. The money value of animal manures cannot be accurately determined for many reasons, so much depends on the season, and circumstances under which they are employed. It is only the theoretical value which chemistry fixes. This is undoubtedly to be trusted, but it often happens that an inferior manure thus tested has a better influence than one which has the highest chemical or theoretical value. It seems to be settled that the value of a manure for a given crop depends upon the quantity of nitrogen it contains, and tables have been constructed which are designed to express this fact. It is assumed, however, that a selected example is represented by a given number, it may be 1000 or 100. This is the standard with which the others are compared, and it may be interesting to consult a table constructed upon this principle, and also occasionally useful. The following is given by Johnson:

| | |
|---|---|
| Farm yard manure, .................... | 100 taken as a standard. |
| Solid excrements of the cow, ............ | 125 |
| " " " horse, ........... | 73 |
| Liquid excrements of the cow, ........... | 91 |
| " " " horse, .......... | 16 |
| Mixed " " cow, .......... | 98 |
| " " " horse, .......... | 54 |
| " " " sheep, .......... | 36 |
| " " " pig, ............ | 64 |
| Dry flesh, .............................. | 3 |
| Pigeon's excreta, ....................... | 5 |
| Flemish liquid manure, .................. | 200 |
| Liquid blood, ........................... | 15 |
| Dry do. ......................... | 4 |
| Feathers, ............................... | 3 |
| Cow hair, ............................... | 3 |
| Horn shavings, .......................... | 3 |
| Dry woolen rags, ........................ | 2½ |

There is considerable truth, no doubt, in the foregoing table, inasmuch as experience supports it so frequently, that in the minds of many it may in fact merit a high degree of confidence. But in the example, woolen rags rank in this scale as high as 2½, that is, 2½ pounds of woolen rags possess as much fertilizing power as 100 pounds of farmyard manure, is doubtful; the practice of wasting them, however, should not be tolerated. According to the chemistry of pigeons' excrements, 5 pounds are worth as much as 100 pounds of farmyard manure. Reliable experience, and all that Johnson* has said of it in another place, seems to sustain in part this view, but all things considered, it is possible it also is ranked too high.

* Johnson's Elements of Agriculture, p. 213—14.

## CHAPTER IX.

Mineral fertilizers. Sulphates. Native phosphates. Carbonates. Nitrates. Silicates. Ashes. Analysis of the ash of the white-oak. Composition of peat ashes. Management of volatile and other fertilizers.

§ 77. As the name implies, *mineral fertilizers* are derived from the mineral kingdom. They comprehend exactly the common elements of soil, and differ from them only in being isolated and in large quantities. Marl does not differ from the carbonate of lime in the soil; phosphate of lime is a soil element, but we procure it in quantities and intermix it with soil, and then call it a *fertilizer*. The process of fertilization consists simply in resupplying what has been removed, or adding it when it is from the start defective, or entirely absent. The farmer, in fertilization, goes to work and supplies from the mineral stores of nature what to him is wanting to make his crops grow.

§ 78. This kingdom is rich in fertilizers, the number exceeds those of both the vegetable and animal kingdoms.

As a class, they are composed of combinations of two and sometimes three elements, which, as a whole, is termed a salt, and they resolve themselves into two parts, a base and an acid; thus sulphate of lime is a salt, and consists of lime, which is the base, and sulphuric acid (oil of vitriol,) which is the acid. Virtually, it seems to be simply a base and an acid; still, lime is a compound of oxygen and calcium, and oil of vitriol of sulphur and oxygen; there is, therefore, three partners in the concern—*oxygen*, *sulphur* and *calcium*. Now in its action, it is not calcium, but *lime;* and though sulphur seems to be dissolved in certain animal fluids, yet it is generally the compound of sulphur and oil of vitriol which is found in the organic tissues. In the mind of the farmer *oil of vitriol* should not be strongly persistent; for, in combining with lime, or iron, or a *base*, this powerful substance loses its sour, caustic properties, and the gypsum formed is really one of the *gentlest, mildest and modest* bodies in the whole mineral kingdom, notwithstanding it contains that audacious consumer of all things, *oil of vitriol.*

§ 79. But we propose to consider somewhat in detail the mineral fertilizers under the heads they are ranked by writers upon agricul-

tural chemistry, and to make such remarks upon them as we may deem useful to the planter.

It need not be inferred, it appears to us, that because a substance is classed with minerals, that its mode of action differs materially from those derived from the vegetable kingdom, or that they are selected by the roots of plants and taken up by them in a different mode. In the vegetable and animal economy, they must be regarded as necessities, and cannot be dispensed with, though in quantity they are necessary only in small proportions.

§ 80. *Sulphates*, are no doubt taken up into the vegetable organism, and if decomposed by the roots or other agencies in the soil without the sulphur which exists in may plants, could not be satisfactorily accounted for. Being taken up as sulphates, the plant has power to decompose them and appropriate the sulphur and the base of the salt.

§ 81. *Sulphate of lime*, or gypsum. This substance is feebly soluble in water. In its purest crystalline condition, it is transparent, and is called *selenite;* when massive it is white or gray, and often granular, or else compact when it forms the common gypsum of agriculture, and which may be distinguished from carbonate of lime or marble by its softness, and not effervescing with acids. It is so soft as to be scratched by the finger nail.

It occurs abundantly in nature, but is never found associated with primary rocks, as granite, mica slate, gneiss, etc. This should be recollected. There is no plaster in North-Carolina unless it is associated with the sandstones of Orange, Chatham or Moore. The agalmatolite, resembling soapstone, has been mistaken for it; indeed, true soapstone is often mistaken for it. Gypsum is usually, too, accompanied with salt springs or salt, and the only indication that possibly gypsum may occur in this state are the feeble saline wells of this formation.

Gypsum appears to have a specific action on the clovers and plants of this natural order, though its activity is less on some species than others. The white clover springs up under the influence of ashes and marls, the red under that of gypsum. Applied directly to many crops, and it is difficult to see that it has benefitted them. This is the case with wheat. No one at present applies it to his crop of wheat directly, but it is first used to grow a crop of clover. This, after being fed off in part by stock, is plowed in and the wheat

then sowed. It is thought by many farmers in the wheat growing districts of New York, that the system of *clover*, *gypsum and wheat*, with alternate rests, is the true system of rotation, and following it the lands will remain as fertile as they ever were. This view, however, it is difficult to reconcile with the fact that several elements are removed with every bushel of wheat sold, which gypsum cannot supply; the natural result, insolvency, ought to follow, as the supply of food is limited.

Gypsum has a fine effect upon the Irish potatoe. It is sown broadcast upon the leaves or foilage when it is hoed the first time. Grass lands are also improved by it. Gypsum appears to be useful to wheat in this way; the grain is first soaked over night, and when wet is rolled in plaster which adheres to it; when it is sown, it is covered with a coat of gppsum. In this mode of use, it seems to aid in bringing it forward, or in promoting an early germination. A remarkable fact with respect to the use of it in the gypsum country of New York, is, that it acts as decidedly upon farms where gypsum exists in beds, as in other parts of the State.

In New York, gypsum has been applied with benefit to all crops but not by every individual. It is said that upon the soil of Long Island it is of no use, and it is accounted for on the ground that the soil is already supplied, or that the sea spray furnishes enough for every crop; certain it is that where the soil has ½ per cent. it is useless to add more. The failure of gypsum is generally due to the fact that there is enough in the soil, if so, it may be determined by analysis.

§ 82. The good effects of gypsnm has been explained in several ways. One theorist has maintained that it is simply a stimulant to plants, or a *condiment.* This view is overhung with doubts. The most rational theory seems to be that it furnishes both sulphur and lime, or is indeed food. Those plants whose growth is strikingly promoted by its use contain notable proportions of both sulphur and lime. Clover, for example, is one; mustard is another. I have already stated that rape seed, which is a mustard plant, contains a large proportion of the former.

The importance of gypsum, or, to be more general, the sulphates, will be best appreciated when it is stated that the most important constituents of our bodies contain and require sulphur.

Thus those parts of the blood which are known as fibrin and serum, as well as the egg of fowls, contain sulphur. This is strikingly manifest when they are in a state of decomposition, as they all give off compounds which exhale the offensive odor of a sulphur compound, well known in the rotten egg;—so also they all blacken silver. Now the bodies named above are all of animal origin, but the sulphur is not disengaged by the animal forces. It is obtained ready formed in the roots and seeds, the cereals and leguminous plants, such as peas, beans and wheat.

To account for the origin of sulphur in animal organisms, it is necessary to go back to the soils, to those salts, such as gypsum, sulphate of ammonia, etc., which contain sulphur in combination. To the vegetable organism is assigned the business of separating this substance from its combinations, and form the roots and seeds spoken of; the animal that feeds upon them obtains, without labor, the sulphur, separated and united with such compounds as we find in the blood, fibrin and serum. The vegetable kingdom thereby becomes a great labor-saving machine to the animal, as all its heavy and complicated duties are performed by it in preparing food for animals. It is not necessary that we should be able to account for changes effected by the vegetable before we can admit the foregoing views. Experiment assures us of the facts in the case. Feed a clover plant or a mustard with gypsum and the sulphur will be found in both.

§ 83. Gypsum is applied at the rate of from 2 to 3 tons per acre broadcast. When used for indian corn it is applied around the hill, and it is regarded as an eminent absorber of water as well as ammonia.

§ 84. When gypsum has been used for many years upon the same ground it ceases to produce an increase of the same crop. The ground is then said to be *plaster sick*. It occurs only with those lands where it exists in excess in the soil in consequence of its free application for a succession of years. The remedy is to suspend its use and substitute wood ashes.

§ 85. *Sulphate of ammonia.*—We place this salt in juxtaposition with gypsum, the object will be seen in the character of the subjoined remarks. As its name implies, it is composed of sulphuric acid and ammonia. We see nothing of it in the soil or elsewhere, unless we take special pains to procure or make it. Sulphate of ammonia

is manufactured from the ammoniacal liquor of gas works from the coal used in the manufacture of gas. If sulphuric acid is added to this liquor, the sulphate will be formed, and some coals yield a liquid which gives 14 oz. of sulphate to the gallon. Sulphate of ammonia is much more valuable than sulphate of lime, as it contains two important elements, sulphur and nitrogen. The nitrogen being much more valuable than the lime. Besides, the animal and vegetable sulphur compounds, fibrin, serum, white of eggs, cascin, etc., contain and require both sulphur and nitrogen. Here in the sulphate of ammonia they exist, and in a salt highly soluble. The simple chemical change required by the plant is to separate the elements of water, hydrogen and oxygen, when the sulphur and nitrogen are in a condition to pass into the compositon of its organism.

This salt will probably be found in the markets of this State, seeing that many of the principal villages have gas works in their suburbs, and may therefore furnish the ammoniacal liquid which may be converted into the sulphate, or it may be used directly, after being greatly diluted.

But sulphate of ammonia may be secured by all persons who keep a stable. This is effected by means of gypsum. If this substance is sprinkled often over the floors of stables, as it should be, it absorbs the ammonia exhaled from excrement of the animals. The ammonia is mostly in the condition of a carbonate. When the gypsum is used in a quantity sufficient to absorb all the escaping ammonia, a large amount of the sulphate will be ultimately formed among the excrements. The gypsum is decomposed by it, and carbonate of lime is the result as it regards the sulphate ot lime, and the sulphuric acid goes over to the ammonia and forms sulphate of ammonia. The advantages of this change are, the ammonia becomes fixed, it is no longer a volatile compound, and there is really no loss attending any of the chemical ones involved in the processes.

The sulphate of ammonia, however, is quite soluble, and should not be exposed to rains out of doors until it is applied to the soil where it is wanted.

From the foregoing we learn several important uses to which gypsum may be put. 1. As an absorbent of injurious and offensive odor. 2. The formation of an important salt—important,

because it contains the elements of blood and muscle. 3. It prevents the destructive chemical changes which ammonia effects in walls plastered with mortar. The lime of the mortar being changed into a nitrate of lime by the formation of nitric acid, which results in the ruin of the plastering. Besides, coaches, harness, saddles, etc., are injured by the escape of ammonia.

The positive economy, therefore, of supplying stables with plaster is too evident to require comment.

Sulphate of ammonia costs in England, ready made, £16 per ton. About one-half cwt. is applied to the acre. It is applied to soils which contain inactive vegetable matter, and it may be mixed with wood ashes, bones, animal and vegetable manures; it may be used as a top dressing to sickly crops, which it revives and regenerates.

§ 86. *Sulphates of patash and soda* are also important fertilizers. The sulphate of soda (glauber salt) possesses a good degree of activity, and is not expensive. It is used successfully upon grasses, clover, green crops and the pea. Its quantity per acre is about one and a half cwt.

*Sulphate of magnesia*, (epsom salts.) Its application to the crops just mentioned is attended with satisfactory results. Magnesia is an important element in all the grains; and hence, where this earth is deficient the sulphate is an elegant compound to be used as a top dressing, for its supply.

§ 87. *Sulphate of iron* (copperas) is an astringent salt, and may be used destructively to a crop. It is a poison, and yet in small doses its use is beneficial to feeble crops, or to fruit trees. It imparts a deeper green to the foliage and appears to give vigor to unhealthy individuals. In these respects its action is similar to that upon the human frame and constitution. It has been used in a weak solution as a top dressing to grass. Two beds of an acid sulphate of iron are known in this State, one in Edgecombe county, the other in Halifax county, near Weldon. A spoonful applied to a hill of corn kills it. To prepare it for use mix with marl. It is by this agent converted into gypsum.

This substance in both cases occurs in a lignite bed, consisting of stems, leaves, and trunks of trees. The organic matter has combined in process of time with sulphate of iron. This, in its turn, or when air has access to it, decomposes and furnishes the

salt in question, and where abundant, is important, provided marl beds are accessible.

§ 88. *Native phosphate of lime.*—This mineral exists in large quantities in New Jersey and New York. The most abundant source of it is in Essex county, New York, in connexion or associated with magnetic iron, where it forms in some part of the vein from one-sixth to one-half its weight. It seems to be inexhaustible. It may be separated from the iron by washing, or by magnets; both methods have been pursued. It exists frequently also, in primary limestones, associated with hornblende, mica, felspar, etc. The great source of phosphate of lime in the soils is probably the granites and other allied rocks. It is present in lavas and other igneous rocks. But it is in minute particles, and rarely when it exists in granite and other compounds is it visible, and is only ascertained to be present by the most careful analysis of the rock.

Other sources of the native phosphate of lime are the sediments which contain fossils. Most, if not all the fossiliferous limestones, the marls of the secondary and tertiary divisions of rocks, furnish it in per centages varying from one to two and a half per cent. In the use of limestones and marls, therefore, as fertilizers, we obtain this important compound as phosphates.

Native phosphate of lime, or as it exists in soils, is quite insoluble in pure water; but for its solution carbonic acid is depended upon in an uncultivated soil. When, however, the planter employs common salt, or salt of ammonia as fertilizers, he provides in part for the solution of phosphate of lime. In sulphate of ammonia, phosphate of lime dissolves as readily as gypsum in water.

§ 89. In North-Carolina the principal source of it is in the marl region. We have never found it in the primary rocks nor associated with any of its iron ores, as in New York and New Jersey, nor in the primary limestones of the mountain belt. The marls all contain it as an organic product, for in every living being it is found both in their hard and soft parts. It is principally in the latter that it exists in the marls. The value of the marls are increased by its presence, and the striking effects of its use may often be attributed to small quantities of phosphate of lime. There are frequently small, round, hard bodies in marl beds, called *coprolites*, which are often in sufficient quantities to pay for selection to be employed in converting them into super-phosphates by sulphu-

ric acid. They contain about 50 per cent. of phosphate of lime. They are hard, and but slightly acted upon by water and the atmosphere, and will therefore remain like rocks, unchanged, and of course benefit the soil but slightly. By the use of an equal weight of sulphuric acid they may be converted into a valuable fertilizer. They would require, however, to be broken into small pieces by a hammer and frequently stirred. A portion would remain in powder, in the form of gypsum. It may be treated like the ordinary super-phosphate of lime made from bones. Super-phosphate of lime is worth about thirty-five dollars per ton.

The practice of burning bones for the purpose of pulverizing them easily is not advisable; it is of course attended with the loss of all the organic matter, and as we believe with effects greatly diminished.

§ 90. *Carbonates.*—The carbonates are the most common of minerals. At the head of the list stands carbonate of lime, known as limestone or marble. Limestone may be known by its effervescing with acids. It cannot be scratched by the nail, but readily by a knife. Its colors are numerous—white, black, brown, flesh-colored, together with shades and tints produced by the oxides of metals, or a mixture of earth. When pure it is white and usually granular, but many limestones of a palaeozoic and mesozoic age are compact. The limestones which are regarded pure are composed of from 96 to 98 per cent. of carbonate of lime. Its chemical constitution is:

| | |
|---|---|
| Carbonic acid, | 43.7 |
| Lime, | 56.3 |

Certain limestones contain also magnesia, which are best known under the name of dolomites. A dolomite is composed of:

| | |
|---|---|
| Carbonate of magnesia, | 45.8 |
| Carbonate of lime, | 54.2 |

When in addition to the magnesia limestones contain 20 per cent. of ferrnginous clay, they form *hydraulic limestones*, which furnish a material, when burned, having the property of becoming hard or solid under water.

The term marble applies to limestones which take a polish. Other limestones are designated by the terms argilaceous and ferrugin-

ous or magnesian, according to the name of the substance which is mixed with the rock.

Limestone is nearly insoluble in pure water, 1 gallon dissolving only 2 grains, but when water is charged with carbonic acid it dissolves freely.

Limestone, when ground finely, might be applied to soils as a fertilizer, but its solution is slow to act. In the form and condition of marl, it is much more efficient.

Quicklime is sometimes important; it is best adapted to stiff clay soils, and is applied for the purpose of making them open and porous. It has also a chemical action which undoubtedly lies at the foundation of its mechanical effects, that of attacking the clay and liberating potash or the alkalies.

Erroneous opinions have been entertained with respect to the action of quicklime on animal and vegetable matter. According to Dr. John Davy, quicklime, instead of promoting fermentation, arrests it in vegetable matters, as peat for example, and as it regards its action upon animal bodies, it only attacks the cuticle, nails and hair, exerting no destructive influence upon the other tissues.

Mixed with peat and vegetable organic matter, it confers a necessary solubility, or rather, the probable action is the formation of an organic salt of lime, which is soluble. This view is sustained by the fact that in the absence of organic matter, lime exerts no perceptible effects. Quicklime should not be mixed with stable manure, unless there is added at the same time *gypsum*, to absorb the *ammonia* which the lime will be instrumental in discharging. Peat, in a state of fineness, may be employed in the absence of gypsum, as its absorbent powers are equally great.

The deficiency of limestone in this State is notorious. The mountains and the region of the Yadkin are tolerably well provided for. The midland counties, which take in a belt over one hundred miles wide, are destitute of it. The lower counties supply carbonate of lime for agriculture in their marl beds, and might also quicklime for building, white-washing, etc. The banks of the Neuse, 20 miles above Newbern, are well stocked with consolidated marl, well adapted in composition for quicklime.

For more than a century, burnt lime has been used in England for the benefit of the soil. It may be shown that potters and brick clay, which are stiff and unyielding, contain potash and other alka-

lies. Now, no plowing, hoeing, or mechanical operation can hasten very materially the liberation of these important elements. No mechanical means effect materially its condition; chemically, they are too slow. If we resort to the use of quicklime, in the fall spreading it over the plowed field, and allow it to act through the winter, the potash will be liberated and the whole field become porous.

§ 91. That form of carbonate of lime which is known as marl, acts more efficiently as a fertilizer than the ordinary air slacked lime. It is not simply a salt of lime alone, but a mixture of fine carbonate of lime, phosphate of lime, magnesia, iron, and some organic matter. Marl appears to be in a more favorable condition than pure lime for an easy solution.

This substance, though it appears inert to the eye, still has to be applied under the guidance of a few rules. It cannot be freely used on poor soils; those, we mean, which are destitute of organic matter. It being an absorbent of water, it is prone to act injuriously upon a crop in dry weather, or to burn it. If on the contrary, the quantity applied is proportionate to the organic matter, it will form soluble combinations adapted to the wants of the crop.

There is no poisonous matter in the marl usually, and the probability is that when in large doses, as 600 bushels to the acre, it deprives the plant of water, being in itself one of the strongest absorbents of moisture known. Where sulphate of iron and alumina are present, this astringent salt being a poison, the plant is killed by its chemical action upon its tissues. As marl is applied to the surface and rarely buried by the plow deeply, it occupies a position which commands all the moisture in a dry time.

To forestall the evils of a large application, it may be composted with peat, or any organic matter; it should always be prepared in this way. But when an over dose has been applied, the most direct mode of neutralizing its bad effects, is to plow it in deeply. It will then become mixed with a large quantity of soil, and all the organic matter of it. It will probably be changed into a fertilizing agent. As used in common cases in this State with the ordinary depth of plowing, a large body of it must effect unfavorably the whole surface, for there is only a few inches of soil for it to act upon.

§ 92. The marls of North-Carolina are not rich in lime, but still remarkable effects are obtained by their use. The following shows

the composition of a marl upon the plantation of Col. Clark, of Edgecombe:

| | |
|---|---|
| Peroxide of iron and alumina, | 6.800 |
| Carbonate of lime, | 16.100 |
| Magnesia, | 0.436 |
| Potash, | 0.616 |
| Soda, | 1.988 |
| Sulphuric acid, | 0.200 |
| Soluble silica, | 0.440 |
| Chlorine, | 0.030 |
| Phosphoric acid, | 0.200 |
| Sand, | 72.600 |

The complex nature of this marl is exhibited in this analysis; it shows that it is adapted to the wants of the vegetable in furnishing as large a list of those elements which the ashes of plants usually contain.

An eocene marl from the plantation of Benj. Biddle, Esq., of Craven county, gave:

| | |
|---|---|
| Sand, | 9.60 |
| Carbonate of lime, | 85.00 |
| Peroxide of iron and alumina, containing phosphoric acid, | 4.40 |
| Magnesia, | trace. |

Those marls which are thus rich in lime, are more liable to be used in excess.

§ 93. The action of the carbonates upon vegetation is usually attributed to the organic salts which are generated in the soil, as the crenates and apocrenates of lime, etc.; but in the formation of these salts it may happen that carbonic acid is set free, and in this condition becomes also a contributor of matter to the growing plant. The carbon of the carbonic acid will be retained in the plant, and the oxygen set free.

The action of marls, as a class of carbonates, upon soils is more favorable in the long run than lime, except where quick lime upon clays is required. The use of lime for many years has induced complaints, whether justly or unjustly, is not perhaps fully settled; but it is charged with exhausting the soil, and like guano, of which

we have spoken, the charge seems to be reasonable enough and to rest on the same grounds.

If the charge is sustained, we can readily see by comparing the composition of marl with common lime, that the former supplies a much greater number of fertilizing elements than the latter; indeed, it is probable that marls, like ashes, contain the most needful elements; and hence, the annual application of marl is not likely to cause an exhaustion of the soil, because of the constant additions made by its use. It rather ought to grow better yearly; for the cotton crop does not require, or does not remove as many pounds of inorganic matter as there are applied. This subject, however, we have not heard spoken of, and we have never heard of injurious effects of marl which could by any means be attributed to exhaustion, and we are confident from the nature of the facts bearing upon the subject, that where especially a compost is made of the marl, it will continue for long periods to produce good effects.

Marl seems well adapted to all those crops where the product sought is made up of cellular tissue, as the lint of cottor, the lint of flax and hemp, the fruit, such as the apple, because lime is the basis of cellular tissue. The phosphoric salts are required in the cereals, the parts sought for must be rich in sulphur and phosphorus. These last are contained in stems, lint, bark, etc., in much less proportions.

§ 94. *Carbonates of potash and soda.*—The first was anciently called the *vegetable*, and the latter the *mineral alkali.* Both, however, are derived from the mineral kingdom, but they are derived for commercial purposes from the ashes of vegetables.

Pearlash is a carbonate of ]otash; it is the common substance used in biscuit making, or short cake, though the bi-carbonate has displaced the old or common carbonate. Neither of these substances have been used extensively in field agriculture. The latter has become a favorite fertilizer for strawberries. Their composition and the fact of their occurrence in the ash of all plants, proves their adaptation to crops. Their cost, however, for general and extensive use, is the only draw-back to their application to corn, wheat, potatoes, etc.

§ 95. *Carbonate of ammonia* is a white salt, with the pungent odor of hartshorn. It exists in the ammoniacal liquids already no-

ticed, and is given off in stables in an impure state, or mixed with the effluvia of animal matters. It is an active fertilizer. Its true value, as in the case of other compounds of ammonia, is due to its ability to furnish nitrogen to vegetation.

As it regards the compounds or salts of ammonia for wheat and other corn crops, it seems to be established that they are essential to the increase of grain, beyond the natural produce of a soil, *aided by phosphatic fertilizers.* The experiments of Mr. Lawes, of Hertfordshire, England, gave the following results:

| APPLICATION PER IMPERIAL ACRE. | | | PRODUCE. In grain. | In straw. |
|---|---|---|---|---|
| 1844. | Super-phosphate of lime, Silicate of potash, | 560 lbs., 220, | 16 bushels. | 1,112 lbs. |
| 1845. | Sulphate of ammonia, Muriate do., | each ½ cwt., | 31½ do., | 4,266 do., |
| 1846. | Sulphate of ammonia, | 2 cwt., | 27 do., | 2,244 do. |

The increase by the salts of ammonia upon the former crop manured by super-phosphate of lime and silicate of potash, is a striking result, and shows that the soil in order to reach its capacity for a crop of cereals, requires, besides the phosphates, those fertilizers which can furnish nitrogen. It does not prove that phosphates can be dispensed with, but only that unless nitrogenous bodies are added the crop will be less.

§ 96 —*Nitrates.*—The union of nitric acid with a base, as potash and soda, constitute *nitrates*, a remarkable class of bodies. They are all soluble and easily decomposed. When thrown upon glowing coals they deflagrate, or burn energetically with flashes of flame and scintillation.

*Nitrate of potash*, *saltpetre*, niter.—Its manufacture illustrates its formation in the soil. If the refuse of old buildings, its mortar, animal refuse, ashes, &c., are mixed in a heap and exposed to the air and watered occasionally, especially with putrid urine, they become charged with nitrates of potash and soda. Whenever, then, the circumstances are favorable, these salts will be formed; the animal matter furnishing the nitrogen which unites as it is developed with oxygen. The elements of the nitrates are found under houses, in caves, or wherever organic matter is mixed with earth protected from rains.

Both nitrates of potash and soda are highly esteemed in agriculture, though the high price of saltpetre debars it from general use. Its action upon young crops, when applied to them at the rate of one cwt. per acre, is highly favorable. Trees, the sugar cane and the grasses become fresh and green, and when combined with the phosphates is one of the most important fertilizers, as it contains in combination, the most important elements which the crop demands—nitrogen, phosphoric acid and potash. Nitrates increase the foliage of plants; and hence, for grass, or meadows, they are particularly and immediately serviceable.

The *nitrate of soda*, sometimes called soda-saltpetre, is a native product of Peru and Chili, being formed in the earth in those sections where rain rarely falls.

§ 97. *Chlorides.*—The compounds consist of chlorine and a base, as sodium, uniting directly, or without the previous union of the base, with oxygen. The most common, and to the agriculturist the most important, is *salt*, or the common table salt. It is a native production in many countries, occurring in solid beds, which have to be quarried like rock. The bed near Cracow, Poland, is supposed to extend 500 miles, and is 1,200 feet thick. Salt springs are common, but the ocean is the great reservoir of salt. It contains about four ounces to the gallon of water. Salt has been and is variously estimated as a fertilizer. It strengthens the straw of the cereals, and is supposed to increase the weight of the grain. It is more important in land, or at a distance from the sea, than upon the shores.

§ 98. *Chloride of ammonia.*—Sal ammoniac of the shops. Muriate of ammonia. This well known salt has proved by experiment, to exercise a beneficial influence upon crops. It is, however, too expensive in its pure state, to be economically employed in agriculture. A solution for steeping seed corn is recommended; it hastens germination, and is supposed also to add to the luxuriance of the crop.

§ 99. *Silicates.*—Pure silica, or pure flint is strictly an acid, but it is so insoluble that under common circumstances its real character is disguised. But put finely ground flints into a solution of potash and the silica unites with the potash, and forms a soluble *silicate of potash.* Silicates, then, are bodies constituted like other salts, having a base united with soluble flint. The silica may be

separated from its combination by the addition of an acid, and the silica will form by itself a gelatinous mass, *which is a silicic acid with water.* If this gelatinous mass is dried, the silica becomes gritty and is really now what is called quartz, and is no longer soluble.

Now in the soil there is always a small quantity of soluble quartz, and certain plants must have it in order to give strength to their stems. All the cereals and grasses are furnished with this substance, which is mainly deposited upon the outside; which both protects and strengthen the straw. It is not properly a nutriment, but in the organization of the grass tribes it is an essential element; wherever the soil is deficient in soluble silica, the straw of the grain is weak. The celebrated German Chemist, Liebig, proposed the use of special manures, consisting of silicates mostly, as a fertilizer for wheat, rye, oats, turnips, &c. His special manures, however, have failed to meet the expectations of his friends. They failed on the ground that mineral substance alone, and by itself, is insufficient to supply the wants of vegetation. The failure has an important bearing on our practical views, showing clearly enough that organic matter is essential to plants. It does not prove that what Liebig proposed was useless and unnecessary, but that he did not go far enough; he fell short of a sound theory by excluding from his potent fertilizers *vegetable matter*, from which the organic acids are formed.

The silicates of rocks are not wholly insoluble, they are attacked by water and carbonic acid, and by their joint action are dissolved. It is by their action that the soil is furnished with soluble silicas. That such a result is possible is shown by the action of rains and carbonic acid upon window glass, while a silicate which becomes gradually opake, especially in stables, where carbonic acid escapes. Distilled water alone dissolves glass. The tumblers used in carbonated spring water are coroded by carbonic acid

Straw furnishes silicates, when spread over the surface of fields, but, if burnt, the silica becomes insoluble. Hence, straw should be applied without change. Its organic matter is also put to use. Straw spread upon meadows for grass is an excellent application.

§ 100. *Ashes* contain a large number of fertilizing elements; indeed it may be presumed that whatever an ash contains performs something in the economy of the vegetable which yields it.

The ash of *sea weeds* is the kelp of commerce. It contains potash, soda, lime, silica, sulphur, chlorine, iodine, etc. The existence of these elements in marine plants throws light on their action upon vegetation.

Wood ashes contain, among other things, *pearlash*, or carbonate of potash. The composition of ashes depends upon the tree and the part burned; the bark furnishes an ash whose composition differs from that of the wood or the leaves.

The ash of the bark and wood of the white oak contains the following substances:

| | SAPWOOD. | BARK. | HEARTWOOD. |
|---|---|---|---|
| Potash, | 13.41 | 0.25 | 9.68 |
| Soda, | 0.52 | 2.57 | 5.03 |
| Sodium, | 2.78 | 0.08 | 0.39 |
| Chlorine, | 4.24 | 0.12 | 0.47 |
| Sulphuric acid, | 0.12 | 0.03 | 0.26 |
| Phos. of peroxide of iron, lime and magnesia, | 32.25 | 10.10 | 13.30 |
| Carbonic acid, | 8.95 | 29.80 | 19.29 |
| Lime, | 30.85 | 54.89 | 43.21 |
| Magnesia, | 0.36 | 0.20 | 0.25 |
| Silica, | 0.21 | 0.25 | 0.88 |
| Soluble silica, | 0.80 | .25 | 0.30 |
| Organic matter, | 5.70 | 1.16 | 7.10 |

The tree furnishing the ash grew upon a clay soil rich in lime. It will be observed that the bark is much richer in lime than the wood, while the wood is richer in phosphates; and the richest part of the wood is that of the outside. The same result is shown in the distribution of potash; the outside wood contains more than the heart wood, and in the bark it is reduced to a minimum quantity, only 0.25 per cent. These are leading facts in the distribution of the elements of growth in the vegetable kingdom, and we may feel assured that it is not an accident that they are thus distributed. It is probable that lime distributed to the outside is best adapted to the protection of the vegetable tissues. The newest parts, as the outside wood, derives a part of its elements from the inside, especially the phosphates, which are no doubt transferred by the circulation. The law which has been already expressed, holds good in all the correct analyses of the parts of trees; their distribution is

upward and ontward, tending continually to the new parts which are being developed.

§ 101. The ashes of peat differ in composition according to the nature of the plant from which peat is formed. There will also be changes in the composition of peat which is old, when compared with a new growth of it.

The following analysis by Johnson, shows the general composition of peat ashes:

| | |
|---|---|
| Chloride of sodium, | 0.41 |
| Phosphate of lime, | 2.46 |
| Sulphate of lime, | 18.66 |
| " magnesia, | 1.68 |
| Carbonate and silicate of magnesia, | 6.32 |
| " " potash and soda, | 5.32 |
| " " alumina, | 11.63 |
| Oxide of iron, | 9.18 |
| Silica, | 15.55 |
| Insoluble matter, sand, &c., | 7.94 |
| Carb. acid, coal, etc., | 10.85 |
| | 100.00 |

In this sample the gypsum is much greater than nsual, and the silicate of alumina is foreign matter, as alumnia is never a true ash product.

§ 102. On reviewing the general principles which are set forth in the preceding account of fertilizers, we may understand that it is not sufficient to apply to the soil fertilizers in their simple state, and at random, provided the planter determines to derive from them the greatest benefit. We are unable to increase their power, but their elements of fertility may be preserved or prolonged by a suitable management, which in reality would be equivalent to an increase of power. The most active and valnable ones require the most particular attention. Guano, for example, requires careful manipulation, and when it is once determined how this volatile compound is to be treated, it furnishes a rule for others whose composition is closely related to it.

Of the different fertilizers, we may arrange them into four orders.

In the first, we may place those which contain a notable per centage of ammonia, in such a state of combination that it is freely exhaled, or exists in a volatile condition.

In the second, those which by chemical changes form ammonia, and which also become volatile.

In the third, we may place the fixed salts; and

In the fourth, those compounds which consist of carbonaceous matters, and possess also the character of comparative stability under ordinary conditions. The latter order is well adapted to a general use with the preceding, either as an absorbent of the volatile matter, especially ammonia, or with the salts, with which they form combinations consisting of an organic acid and a mineral base.

The probability is that the best results are secured by mixing our organic with the inorganic in every instance. By adopting this course, the time when soils will begin to exhibit signs of exhaustion will be far in the future, or certainly postponed indefinitely.

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## CHAPTER X.

The quantity or ratio of the inorganic elements in a plant may be increased by cultivation. Source of nitrogen. Specific action of certain manures, particularly salts. Farm yard manure never amiss. Use of phos. magnesia. Special manure sometimes fails, as gypsum.

§ 103. While it is well established that the organs of plants possess each their own component, inorganic elements, it is equally well proved that their quantity may be increased or diminished by modes of cultivation. The organs still maintain their differences in respect to the ratio of the component elements under any system of culture.

As an illustration of the changes which may be produced by modes of cultivation, we may cite wheat. If, for example, it is

manured with the ejecta of the cow, it furnishes a smaller proportion of gluten than if manured with fertilizers richer in ammonia. When manured as above, the berry contained 11.95 parts of gluten, and 62.34 of starch. When manured with human urine, which is rich in the elements of ammonia, it yielded 35.1 of gluten; nearly three times as much as in the former case. Gluten determines the weight of the grain, and, to a certain extent, its use. The flour, which is suitable for the manufacture of maccaroni, must be rich in gluten. Certain soils produce, without fertilizers, a heavy wheat rich in gluten. This is a fact with the wheat of Stanly county, N. C., which weighs 68 lbs. to the bushel, probably the heaviest wheat ever sent to market.

§ 104. The important principle contained in the foregoing facts have a practical bearing; they determine the practicability of raising a crop adapted to a particular use, independent of the influence of climate, and hence of increasing its value.

In relation to the subject of ammonia, much thought has been given, and many experiments made to settle the question of its source. As nitrogen forms a large proportion of the atmosphere, it was natural to infer that the atmosphere might furnish this element directly to the leaves or to some other part of the plant. This view has not been adopted, and it is moreover well settled that ammonia exists in the air in small quantities and is dissolved in rain water; it is also contained in fresh fallen snow, but notwithstanding its presence in the atmosphere, it is essential to its reception in the plant to combine it with an organic acid, which nature effects in the soil, which contains organic matter, in the condition of acids, as the cerenic and apocrenic.

Certain other saline manures exercise a specific action upon crops. Those of ammonia are, perhaps, the most general in their effects; all crops continue to grow longer under the influence of these salts, or continue in a growing state until late in the season. Nitrate of soda has a similar effect. With respect to their application to certain crops, which we wish to have ripened within a certain period, as *tobacco*, for example, they would not be adapted to it; it would cause the plant to continue growing until frost; it would be in the unripened state, or only ripened in part; and hence the tobacco would command only an inferior price in market.

§ 105. Certain salts promote the growth in perfection of particular parts of vegetables. Thus when the straw of wheat or rye is weak, theory would lead to the use of the soluble silicates of lime or potash, for the purpose of supplying the silex where it is required. The practice is attended with good results. When the ear is not well filled, the phosphates are resorted to, as it is here that this salt is deposited in the greatest quantity. The leaves of the vine are best developed by carbonate of potash; and the phosphates again develope or go to the fruit.

Other fertilizers seem to be adapted in certain conditions at least to all crops. Farm-yard manure never comes amiss, provided it has been subjected to such physical and chemical changes which the crop requires. It is not always proper to apply it fresh or in the condition of long manure. Gypsum is specially adapted to the growth of red clover, and ashes and marl will bring up white clover in places where it had not been known to grow perhaps at all.

Phosphate of magnesia has been praised for potatoes, and the super-phosphate of lime is the best dressing for turnips.

But even the foregoing well authenticated facts are somewhat local; for certain reasons not well ascertained, some of the striking effects of these special results, do not occur in another section of the country, or at least are far from being so striking It is never possible to predict the effects of gypsum on crops, though its properties must hold good everywhere; that is, must always act as an absorbent of ammonia and water, but still it is said to fail at times as a fertilizer. In England it is not particularly praised, while in this country there are only a few districts where it is not attended with benefit to the crop. Natural fertilizers, however, do not stand alone in their failures. Those manufactured for a particular end are found to fail frequently. Failures no doubt occur by a misapplication of the substance; it may be given in excess and become a destroyer. It may fail from an unfavorable season, and may also fail from adulteration or for want of a natural purity in composition as a great excess of inert and valueless substance with which it is intermixed.

# CHAPTER XI.

On the periodical increase of the corn plant. The white flint, together with the increase of leaves and other organs. The proportions of the inorganic elements in the several parts of their composition. The quantity of inorganic matter in an acre of corn and in each of its parts. Remarks upon the statistics of composition.

§ 106. The changes which a plant undergoes during its period of growth are worthy of attention. For the purpose of illustrating the development of vegetable organs, we have selected the Indian corn or maize; and as the growth of the foliage exhibits the views we wish to bring out, we have tabulated the weekly increase of the leaves in weight, and the amount of water they contain, together with the quantity of ash the whole weight furnishes. The observations begin in July and are continued until August 11:

| TIME: | JULY 5. | JULY 12. | JULY 18. | JULY 29. | AUGUST 4. | AUGUST 11. |
|---|---|---|---|---|---|---|
| Weight in grains, | 367. | 698 | 886 | 2294 | 2810 | 1642 |
| Water, | 304 | 568 | 869 | 1835 | 2179 | 1227 |
| Ash, | 6.75 | 756 | 8.32 | 41.58 | 58.97 | 36.59 |

This table shows the rapid increase of weight in the leaves from July 18 to August 4, after which the leaves rapidly lose their weight, by supplying, no doubt, nutriment to the corn, which is then filling up. There is in most organs a growth which attains its maximum at a certain period, when it seems to retrograde. This view, however, applies only to the subsidiary organs All the energies of a plant are concentrated on the production and perfection of seed. The stalks of corn increase in about the same ratio as the leaves.

| STALKS. TIME: | JULY 5. | JULY 12. | JULY 18. | JULY 24. | AUG. 4. | AUG. 11. |
|---|---|---|---|---|---|---|
| Weight in grains, | 100 | | 1084 | 3041 | 5219 | 4597 |
| Water, | 92 | | 987 | 2671 | 4525 | 3832 |
| Ash, | 94 | | 8 | 16.82 | 29.48 | 51.25 |

§ 107. The stalk attains its maximum growth between by the 4th and before the 11th of August, and begins to yield up its nutriment to the ear, which is rapidly forming. By the 23d of the

month, a week later, they weigh 2,237 only. In the selection of specimens, it was attempted to employ such as were equally advanced and of equal size, as possible.

§ 108. The increase in weight of the white flint corn during periods of one week and during the period embraced in the foregoing observations, will be expressed in the following tables and remarks.

On the 28th of June the corn was 18 inches high, and had increased in height during the preceding week 7½ inches:

| | | |
|---|---|---|
| Average weight of each plant, ............ | 84.15 | grs., |
| Increase in weight, ........................ | 62.05 | " |

July 5th, hight 26 inches; increase in hight, 8 inches:

| | | |
|---|---|---|
| Weight of one plant, .................... | 237.5 | grs., |
| Increase of weight during the week, ....... | 152.35 | " |
| Average increase of one plant per day, ..... | 21.76 | " |

July 12th, hight of plants 35 inches; increase 9 inches:

| | | |
|---|---|---|
| Weight of one plant, .................... | 861.9 | grs., |
| Increase per week, ....................... | 432.7 | " |
| " day, ....................... | 61.81 | " |

July 19th, hight 43 inches; increase in hight 8 inches:

| | | |
|---|---|---|
| Average weight of each plant, ............ | 875.48 | grs., |
| Increase during the week, ................ | 177.19 | " |
| Increase per day, ........ .............. | 25.31 | " |

July 26th, hight 49 inches; increase in hight 6, or one inch per day:

| | | |
|---|---|---|
| Average weight of each plant, ........... | 2039. | grs., |
| Increase per week, ..................... | 1191.6 | " |
| Increase per day, ....................... | 170.22 | " |
| Increase per hour, ..................... | 7.09 | " |

August 2d, hight 58 inches; increase 9 inches:

| | | |
|---|---|---|
| Average weight of each plant, ........ ... | 3308. | grs. |
| Increase in weight per week, ............ | 1269. | " |
| Average per day, ......................... | 181. | " |
| Average per hour, ....................... | 7.55 | " |

August 9th, hight 65 inches; increase during the week 7 inches:

| | | |
|---|---|---|
| Average weight of each plant, ....... .... | 38.27 | grs., |
| Increase during the week, ................. | 286. | " |
| Increase per day, ........................ | 11.92 | " |
| Increase per hour, ....................... | .49 | " |

August 16th, average hight 72 inches; increase 7 inches:

| | | |
|---|---|---|
| Average weight of each plant, .......... | 6780 | grs., |
| Increase of weight during the week, ....... | 2953 | " |
| Increase per day, ........ .............. | 436 | " |
| Increase per hour, ...................... | 18.16 | " |

August 23rd, average increase in hight of plants for the week .76 inches; increase in hight during the week 4 inches:

| | | |
|---|---|---|
| Average weight of each plant, . ......... | 8170. | grs., |
| Increase in weight, .................... | 1389. | " |
| Average per day, ...................... | 198. | " |
| " per hour, ...................... | 8.27 | " |

August 30th, average hight 78 inches; increase in hight during the week 2 inches:

| | | |
|---|---|---|
| Average weight of each plant, ............ | 10.580 | grs., |
| Increase during the week, ................. | 2.409 | " |
| Increase per day, ....................... | 344 | " |
| " per hour, ..................... | 14.34 | " |

September 6, average hight of each plant, 78 inches. No increase in hight for the week:

| | | |
|---|---|---|
| Average weight of each plant, .......... | 12.917 | grs., |
| Increase during the week, ............. | 2136. | " |
| Increase of weight per day, ............ | 305. | " |
| Increase of weight per hour, ........... | 12.72 | " |

On comparing the parts of the plant with each other at this stage of growth, we find they hold the following proportions to each other:

6

| | Weight. | | | |
|---|---|---|---|---|
| Tassel, | 147.98 | grs., | 2.29 | per cent. |
| Upper part of the stalk, | 1128.8 | " | 0.63 | " |
| Lower part of the stalk, | 2084. | " | 1.13 | " |
| Sheaths, | 1239. | " | 1.42 | " |
| Leaves, | 1970. | " | Lost. | |
| Ear stalks, | 1217. | " | .48 | " |
| Husks, | 2484. | " | 1.65 | " |
| Kernels, | 926. | " | .488 | " |
| Cob, | 1255. | " | .354 | " |

The composition of the ash of the leaves and sheaths at this stage of growth is as follows:

| | Leaves. | Sheaths and Husks. |
|---|---|---|
| Potash, | 10.15 | 8.76 |
| Soda, | 22.13 | 19.68 |
| Lime, | 3.38 | 1.20 |
| Magnesia, | 2.38 | 2.02 |
| Earthy and alkaline phosphates, | 14.50 | 13.80 |
| Carbonic acid, | 3.50 | 4.14 |
| Silicic acid, | 36.27 | 38.10 |
| Sulphuric acid, | 5.84 | 6.36 |
| Chlorine, | 1.63 | 4.34 |

At a later period, that of October 18th, when the corn was ripe, the leaves and sheaths were composed of:

| | Leaves. | Sheaths. |
|---|---|---|
| Potash, | 8.33 | 7.48 |
| Soda, | 8.52 | 12.44 |
| Lime, | 4.51 | 2.13 |
| Magnesia, | 0.86 | 0.79 |
| Phosphates, | 6.85 | 9.75 |
| Silicic acid, | 58.65 | 51.25 |
| Carbonic acid, | 4.05 | trace. |
| Sulphuric acid, | 4.88 | 12.27 |
| Chlorine, | 2.66 | 2.96 |

§ 109. The stalks of the period were composed of:

| | STALKS. |
|---|---|
| Potash, | 16.21 |
| Soda, | 24.69 |
| Lime, | 2.84 |
| Magnesia, | 0.93 |
| Phosphates, | 16.15 |
| Silicic acid, | 12.85 |
| Carbonic acid, | 1.85 |
| Sulphuric acid, | 10.73 |
| Chlorine, | 10.95 |

The phosphates of the leaves of the October's growth are less than in those of September 6. The amount of the alkalies have apparently diminished, though it is possible that comparisons may be fallacious, seeing that the results are obtained from the analysis of different plants, growing also on different hills, and may prove to be due to other causes than those connected with the distribution of inorganic matter by the influence of the organs. Our theory is, with respect to the distribution of the inorganic matter, that the leaves furnish to the grain a part of their store, or that it is transferred from the leaf to the grain.

The husks are composed of:

| | HUSKS. |
|---|---|
| Potash, | 3.51 |
| Soda, | 9.82 |
| Lime, | 0.45 |
| Magnesia, | 0.07 |
| Phosphates, | 26.25 |
| Silicic acid, | 47.65 |
| Sulphuric acid, | 6.67 |
| Chlorine, | 5.56 |
| Carbonic acid, | trace. |

For feeding stock, horses, cows, etc., the advantages of one organ over the other are not very great, so far as the inorganic matter is concerned. The silicic acid or silica is the greatest in the husks, which may be regarded as the useless part; but it happens that the *phosphates* are greater in the husks than the leaves at this stage; but again, the potash and soda are greatest in the leaves.

In the sheath and leaves, taken at the same date, Sept. 6, there are but slight differences in composition in the two organs, leaf and husks. A comparison of the composition of the leaves and the grain of the white flint corn of August 22:

| | LEAVES. | GRAIN. |
|---|---|---|
| Potash, | 12.76 | 23.92 |
| Soda, | 8.51 | 22.59 |
| Lime, | 6.09 | 0.16 |
| Magnesia, | 1.25 | 2.41 |
| Alkaline and earthy phosphates, | 19.25 | 35.50 |
| Silica, | 50.55 | 9.50 |
| Sulphuric acid, | 4.18 | 4.38 |
| Chlorine, | 9.76 | 0.40 |

The alkaline and earthy phosphates, potash and soda, exist in large proportions in the grain, while the silica is reduced to a minimum, and is confined to the cuticle.

§ 110. Analysis of the grain and cob of the 8 rowed yellow corn of the same ear:

| | GRAIN. | COB. |
|---|---|---|
| Potash, | 27.35 | 37.85 |
| Soda, | 5.79 | 1.83 |
| Lime, | trace. | 0.24 |
| Magnesia, | trace. | 0.53 |
| Earthy and alkaline phosphates, | 52.75 | 36.57 |
| Chlorine, | 4.10 | 2.95 |
| Sulphuric acid, | 3.48 | 9.20 |
| Silex, | 1.73 | 10.76 |
| Per centage of ash, | .62 | .40 |

As it regards the value of the cob for nutriment so far as its inorganic matter is concerned, it is plain that it has a certain value and should not be lost. Cob ashes are known to be rich in the alkalies even when guided only by taste; but at this stage the potash amounts to 37 per cent. and the phosphates to 36 per cent. and the silica to only ten per cent. But the per centage of ash is small in the cob, scarcely amounting in any case to more than one-half of one per cent.

§ 111. The husks of this variety of corn and which belong to the same stage of growth, are composed of:

| | |
|---|---|
| Potash, | 21.85 |
| Soda, | 2.04 |
| Carb. of lime, | 0.27 |
| Magnesia, | 0.23 |
| Phos. of lime, magnesia and iron, | 29.43 |

| | |
|---|---|
| Chlorine, | 1.11 |
| Sulphuric acid, | 11.11 |
| Silica, | 32.13 |

From observation and experiment it appears highly probable. that the 8 rowed yellow corn is one of the most valuable for feeding properties. Its parts are all of them rich in inorganic matter.

§ 112. Upon an acre of corn we raise about 18,700 plants. These plants will contain 466.80 lbs. of inorganic matter. This inorganic matter will be distributed to the parts of plants in the following amounts:

| | | |
|---|---|---|
| Tassels, | 64.239 | grs., |
| Stalks, | 525.525 | " |
| Sheaths, | 594.962 | " |
| Leaves, | 1.195.845 | " |
| Silks, | 25.284 | " |
| Husks, | 434.091 | " |
| Cobs, | 264.600 | " |
| Grain, | 480.690 | " |
| | 3.585.036 | grs.,=7468.82 oz.=466.80 lbs. |

Of this quantity the leaves and sheaths will contain of:

| | LEAVES. | | SHEATHS | |
|---|---|---|---|---|
| Silica, | 82.681 | pounds, | 39.667 | pounds, |
| Earthy phosphates, | 29.273 | " | 7.546 | " |
| Lime, | 9.400 | " | 1.581 | " |
| Magnesia, | 1.910 | " | 0.589 | " |
| Potash, | 19.704 | " | 5.571 | " |
| Soda, | 13.142 | " | 9.262 | " |
| Chlorine, | 15.072 | " | 2.202 | " |
| Sulphuric acid, | 6.461 | " | 8.928 | " |

The weight of the inorganic matter of the grain and cob will be:

| | GRAIN. | COB. |
|---|---|---|
| Silica, | 5.939 | 4.678 |
| Earthy and alkaline phosphates, | 22.187 | 8.229 |
| Lime, | 0.187 | 0.103 |
| Magnesia, | 1.506 | 0.309 |
| Potash, | 14.950 | 12.315 |
| Soda, | 14.118 | 2.034 |

| | | |
|---|---|---|
| Chlorine, | 0.309 | 0.045 |
| Sulphuric acid, | 2.740 | 0.118 |

The stalks of one acre will contain:

| | |
|---|---|
| Silica, | 8.789 |
| Earthy phosphates, | 10.362 |
| Lime, | 1.928 |
| Magnesia, | 0.640 |
| Potash, | 11.087 |
| Soda, | 17.094 |
| Chlorine, | 7.491 |
| Sulphuric acid, | 7.382 |
| | 64.773 pounds. |

§ 113. The several amounts of the inorganic elements will stand as follows:

| | LBS. OZ. DECIMAL PARTS OF AN OUNCE. |
|---|---|
| Silica, | 173.12.496 |
| Earthy phosphates, etc., | 93. 3.984 |
| Lime, | 13. 9.248 |
| Magnesia, | 5. 0.752 |
| Potash, | 66. 2.944 |
| Soda, | 61.15.184 |
| Chlorine, | 28. 7.328 |
| Sulphuric acid, | 29.11.696 |
| | 471.15.632 |

§ 114. The foregoing statistics of the corn or maize elements show that it is an exhausting crop. This is agreeable to the opinions of the best informed farmers.

The maize crop is remarkable for bearing high culture without danger of an excessive growth of stalk or leaves. In this respect it is quite different from wheat or oats. The rich lands of the eastern counties of North-Carolina produce great crops of maize, but when wheat is put upon them, the crop consists of straw instead of grain, which is even of a poor quality, so far as it is produced.

Again, the foregoing statistics show the actual amount which each part contains, and what it removes from the soil. An infer-

ence from all these facts is, that it is not sufficient to supply the phosphates upon an exhausted soil to restore it to fertility; the quantity of potash, soda, etc., which may be and probably is combined in part with silica, shows that the soluble silicates will be required in the list of fertilizers. Plants require *foliage elements*, as well as *grain or seed elements;* for undoubtedly the perfection of the seed is dependent, in a great measure, upon the perfection of the foliage. This precedes, or is developed first, and when we find it green and luxuriant, we predict a fine crop of grain.

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## CHAPTER XII.

Value of foliage for animal consumption depends upon the quantity of two different classes of bodies: heat producing and flesh producing bodies. These two classes are the proximate organic bodies, and are ready formed in the vegetable organs. Proximate composition illustrated by two varieties of maize. Their comparative value. Analysis of several other varieties of maize for the purpose of illustrating difference of composition as well as their different values. Composition of timothy, etc.

§ 115. The true value of foliage is determined from the quantity of the proximate elements of certain organic products developed or produced in the organs and seeds of many plants, particularly those which are in common use for feeding animals. Of these elements starch, sugar, gum, dextrine, gluten, legumen, casein, albumen, are the most important. The list is naturally divisible into two classes. The four first form a class which have been called respiratory elements, and furnish the body with heat and fat; they are destitute of of nitrogen. The remainder, of which gluten stands at the head, are the flesh and strength producing elements, and are known to contain nitrogen, and hence are sometimes called *nitrogenous elements.* The first class meet a special want in the animal economy, that of supplying it with heat, and when they are taken in larger quantities than the system requires, they accumulate around certain parts in the form of fat.

It is evident that as the economy of the animal system requires not only heat but strength and muscle or flesh, and as these are furnished from plants in the first place, that any given plant is valuable for food in proportion to the quantity which these two classes of elements are contained in the vegetable or which it can furnish. In order to determine the value of a plant, then, these different classes and individuals of the class are separated or isolated from their natural combinations, or in other words they are analyzed. As an example we may take the composition of maize, which will show the proximate composition of the grain. Its ultimate analysis would be, resolve the proximate bodies into the elements, carbon, oxygen, dydrogen and nitrogen. The proximate elements exist ready formed in the *grain, leaf or stem*, and they are separated from the fibre or cellular tissue by water, alcohol, ether, weak alkaline, solutions, etc. The grain, then, in its proximate elements of ready formed bodies, contains:

| | 8 ROWED WHITE FLINT. | WHITE KENTUCKY DENT CORN. |
|---|---|---|
| Starch, | 57.47 | 50.92 |
| Oil, | 2.55 | 0.64 |
| Dextrine or gum, | 4.01 | 3.08 |
| Sugar and extractive, | 13.21 | 13.80 |
| Albumen, | 2.27 | 4.44 |
| Casein, | 0.39 | 0.80 |
| Gluten, | 1.67 | 0.72 |
| Fibre, | 6.07 | 9.70 |
| Water, | 11.46 | 12.22 |

The heat producing bodies in the two varieties are:

| | FLINT. | KENTUCKY CORN. | |
|---|---|---|---|
| Starch, | 57.47 | 50.92 | |
| Oil, | 2.55 | 0.64 | |
| Gum, | 4.01 | 3.08 | |
| Sugar, | 13.21 | 13.80 | |
| | 77.24 | 68.42 | Heat and fat producing bodies. |

While the flesh producing are in the

| | FLINT CORN. | KENTUCKY CORN. |
|---|---|---|
| Albumen, | 2.27 | 4.44 |
| Casein, | 0.39 | 0.80 |
| Gluten, | 1.67 | 0.72 |
| | 4.33 | 5.96 |

In the Kentucky corn the flesh producing bodies exceed those in Flint corn.

To give another analysis of corn for the purpose of showing a still greater difference in the varieties often cultivated, we select the small blue corn used for parching. It contains:

| | |
|---|---|
| Starch, | 42.56 |
| Oil, | 5.30 |
| Sugar and extractive, | 15.32 |
| Gum, | 7.52 |
| Albumen, | 5.00 |
| Casein, | 2.04 |
| Gluten, | 4.78 |
| Fibre,* | 8.56 |
| Soluble in fibre by potash, | 8.55 |

The fine parching properties of this corn are due to the large quantity of oil present in the grain. Another variety of *pop corn*, the lady finger, contains nearly 7 per cent. of oil.

The sweet corn is still more remarkable in its composition, thus it contains:

| | |
|---|---|
| Starch, | 11.60 |
| Oil, | 3.60 |
| Sugar, | 6.62 |
| Dextrine or gum, | 24.82 |
| Extract, | 8.00 |

* Fibre is the hard stringy part of vegetables; it is wood or the fibre of flax; cotton lint is the purest form of fibre; bruise or beat wood or straw or grain, dissolve out by water, ether, alcohol and a weak solution of pearlash all that can be and the part remaining is fibre; it exists in the excrements of cattle and horses, and forms much of their bulk.

| | |
|---|---|
| Gluten, | 4.62 |
| Albumen, | 14.30 |
| Casein, | 5.84 |
| Fibre, | 11.24 |
| Water, | 10.81 |

The starch in this variety is reduced to a minimum quantity, and the gum or dextrine is increased to the maximum known in maize. The gum, no doubt, replaces in part the starch, and it is this element which causes the great shrinkage in the kernel, from which we should very naturally infer that the corn was gathered in an unripe condition. This, however, is not the fact. But the sweet corn is eminent for its flesh producing elements when it is seen to contain 14 per cent. of albumen and 5 per cent. of casein.

§ 116. The value of the corn leaf, or fodder, as it is called, is more accurately ascertained by submitting it to an organic proximate analysis. When thus treated timothy and corn leaf are found to be composed of:

| | TIMOTHY. | CORN LEAF. |
|---|---|---|
| Fibre, | 68.14 | 60.00 |
| Wax, | 2.80 | undetermined. |
| Sugar extract and dextrine, | 8.20 | 10.00 |
| Albumen, | 1.89 | 0.22 |
| Casein, | 2.34 | 1.60 |
| Water, | 12.30 | 10.17 |

The insoluble fibre makes the bulk of the leaf, and serves in the animal economy to fill up space, or give a proper degree of tension to the membranes. The albumen and casein are nearly as large in corn leaf as in the best of grasses. The red top, a favorite hay, is composed of:

| | |
|---|---|
| Fibre, | 65.00 |
| Wax, | 11.62 |
| Resin, | 3.08 |
| Extract and sugar, | 9.00 |
| Albumen, | 1.49 |
| Casein, | 1.80 |
| Water, | 10.00 |

§ 117. It will be observed that the insoluble matter, or fibre, in the three kinds in the above examples, timothy, red top and corn leaf, are really the same, or nearly so. All the other bodies, classed as *nutritive and fat producing*, make up the remainder. They differ in quantity in these individual specimens, yet, it is probable, that for feeding stock, as they generally grow, sometimes on rich and sometimes on poor soil, they cannot differ essentially. One, in its general run, will support as much stock as the other, for it will be observed that cultivation, or no cultivation, changes the character of the crop. If, however, we compare the foregoing compositions with another species, which grows naturally on a cold wet soil we shall perceive a great difference.

For example, a carex (a swamp grass) collected just before it was to blossom was found to be composed of:

| | |
|---|---|
| Fibre, | 86.20 |
| Wax, | 2.00 |
| Albumen, | 2.84 |
| Casein, | trace. |
| Resin, | 0.47 |
| Extract and sugar, | 6.60 |

The greatest part of this grass is unnutritious fibre, still it is not deficient in albumen, but both classes of bodies are reduced to a low per centage. We find less than 15 per cent. of the heat and flesh producing bodies combined.

Composition of the common garden pea, rice and wheat, so far as their proximate organic elements are concerned :

| | PEA. | RICE. | WHEAT. |
|---|---|---|---|
| Water, | 14 | 13 | 15 |
| Starch, | 42 | 70 | 42 |
| Sugar and gum, | 6 | 4 | 9 |
| Nitrogenous substances, | 24 | 7 | 15 |
| Oil, | 2 | 1 | 2 |
| Woody fibre, | 9 | 4 | 15 |
| Ash, | 3 | 1 | 2 |
| | 100 | 100 | 100 |

Rice contains a larger amount of stalk than wheat or corn, but in nitrogenous substances it is less than one-half of that in wheat, and in the pea they exceed the rice more than three times.

## CHAPTER XIII.

Composition of tuberous plants with respect to their nutritive elements. Irish potatoe. Sweet potatoe. Their nutritive values compared.

§ 118. The family of vegetables which rank next in nutritive value to the cereals are the tuber bearing plants, potatoes, sweet potatoes, turnips, etc. They owe their value mostly to the presence of the same heat and flesh producing bodies as the grains. The inorganic elements are the same as in the cereals and grasses, but their proportions differ somewhat from them. The ash of the mercer potatoe, which is, in general repute, is composed of:

| | MERCER POTATOE. |
|---|---|
| Silica, | 4.40 |
| Earthy and alkaline phosphates, consisting of lime, magnesia and iron, | 39.50 |
| Lime, | 0.15 |
| Magnesia, | 0.80 |
| Potash, | 14.26 |
| Soda, | 24.92 |
| Sulphuric acid, | 6.25 |
| Carbonic acid, | trace. |

A curious fact which we brought out in the analysis of the potatoes is the difference in the proportion of both water and ash of the ends, and besides the rose end, if planted, will form potatoes earlier than the heel end. They are composed of:

| | ROSE END. | HEEL END. |
|---|---|---|
| Water, | 83.83 | 75.17 |
| Dry matter, | 16.16 | 24.82 |
| Ash, | 0.72 | 0.43 |

§ 119. The proximate organic analysis of the tuber of the mercer gives us more information, as it regards its nutritious qualities. It contains:

| | |
|---|---|
| Starch, | 9.71 |
| Fibre, | 5.77 |
| Gluten, | 0.20 |

| | |
|---|---|
| Fatty matter, | 0.08 |
| Albumen, | 0.24 |
| Casein, | 0.50 |
| Dextrine, | 0.72 |
| Sugar and extract, | 3.93 |

The water of the potatoe amounts to about 80 per cent. The starch is less in this sample of mercer than in the early June, which contains 13.37 per cent. As it regards flesh producing bodies all the potatoes rank low.

§ 120. The following analysis of the sweet potatoe will enable the reader to compare it with the Irish as an article of food, particularly with regard to its flesh producing qualities. The ash is composed of:

| | |
|---|---|
| Silica, | 1.85 |
| Earthy and alkaline phosphates, | 22.10 |
| Carbonate of lime, | 0 60 |
| Magnesia, | 0.50 |
| Potash, | 49.36 |
| Soda, | 5.02 |
| Sulphuric acid, | 1.20 |
| Chlorine, | 4.09 |
| Carbonic acid, | 15.72 |
| | 98.91 |

The tuber contains:

| | |
|---|---|
| Water, | 69.51 |
| Dry matter, | 30.48 |
| Ash, | 1.09 |

§ 121. The proximate organic analysis gave:

| | SWEET POTATOE. | TURNIPS. |
|---|---|---|
| Starch, | 19.95 | 7 |
| Sugar and extract, | 5.80 | 2 |
| Dextrine, | 0.75 | |
| Fibre, | 1.85 | 2 |
| Matter dissolved by potash, | 2.10 | |
| Albumen, | 5.90 | 1½ |
| Casein, | 1.03 | |
| A body that resembles balsam, | 0.22 | ½ oil. |
| Water, | 96.56 | 86 |

The foregoing analyses serve to confirm or rather to agree with the common opinion, that the sweet potatoes rank considerably higher in the scale of nutriment than the Irish; they furnish more of the flesh producing bodies; they contain less water. Both are rich in potash. The per centage of ash appears low, but in both it is extremely fusible and difficult to obtain in a pure condition for weighing, as it is very liable to be caustic. The ash of the leaves and stems is composed of:

| | |
|---|---|
| Silica, | 23.60 |
| Earthy phosphates, | 28.57 |
| Carbonate of lime, | 15.00 |
| Magnesia, | none. |
| Potash, | 18.51 |
| Soda, | 9.46 |
| Sulphuric acid, | 2.78 |
| Chlorine, | 2.09 |
| Per cent. of ash in leaves, | 2.63 |
| " " stems, | 1.73 |

The sweet potatoe compared with the turnip used so largely for fattening stock in England, is far superior in every point of view.

---

## CHAPTER XIV.

Composition of the ash of fruit trees; as the peach, apple, pear, Catawba grape. Amount of carbon or pure charcoal which some of the hard woods give by ignition in closely covered crucibles.

§ 122. Persons who cultivate fruit trees may wish to know the composition of the inorganic matter or ash which the different parts furnish. The following analysis will fulfil in part, at least, their wishes. The peach being a very important fruit tree in this State, is selected from among many which have been made. The ash of the parts of the peach is composed as follows:

| | BARK. | WOOD. | LEAVES. |
|---|---|---|---|
| Potash, | 2.20 | 7.11 | 12.41 |
| Soda, | | 11.15 | |
| Chlorine of sodium, | 0.04 | 0.16 | 0.36 |
| Sulphuric acid, | 4.19 | 1.51 | 12.12 |
| Lime, | 42.17 | 22.26 | 14.77 |
| Magnesia, | 2.16 | 6.40 | 8.00 |
| Phosphate peroxide of iron, | 0.45 | 0.32 | 2.47 |
| Phosphate of lime, | 9.79 | 26.19 | 10.44 |
| Phosphate of magnesia, | 0.51 | 1.34 | 3.15 |
| Silica, | 4.15 | 1.35 | 6.42 |
| Coal, | | | 4.48 |

In the foregoing analysis the carbonic acid was undetermined. It appears from the analysis that sulphates, gypsum probably, will have good effects upon the peach tree. The leaves in another analysis made in July, gave:

| | PEACH LEAVES. |
|---|---|
| Potash, | 14.28 |
| Soda, | 21.22 |
| Lime, | 16.22 |
| Magnesia, | 5.90 |
| Phosphate, | 11.60 |
| Sulphuric acid, | 4.42 |
| Chlorine, | 5.12 |
| Carbonic acid, | 14.30 |

The pits of a peach are rich in lime, phosphate of lime and silica. Lime must hold an important place as a fertilizer for the peach tree, provided we attempt to fulfil the indications furnished by the composition of leaves, wood and bark. The alkalies, potash and soda, are also to be supplied. Ashes, however, will supply all its wants.

§ 123. Composition of the leaves of the pear and apple tree at the time when the flowers had just fallen:

| | APPLE TREE LEAVES. | PEAR TREE LEAVES. |
|---|---|---|
| Potash, | 27.17 | 18.95 |
| Soda, | 11.83 | 15.19 |
| Lime, | 3.38 | 4.71 |
| Magnesia, | 2.74 | 4.50 |
| Chlorine, | 0.79 | undetermined. |
| Phosphates, | 26.60 | 25.05 |

| | | |
|---|---|---|
| Sulphuric acid, | 10.12 | undetermined. |
| Silica, | 4.65 | 1.75 |
| Carbonic acid, | .55 | 11.56 |

Both the apple and pear leaves are rich in alkalies as well as phosphates. Whether an analysis in September would furnish similar results is doubtful, as it is believed that there may be a transference of these bodies to the maturing fruit.

§ 124. Analysis of the ash of the leaves of the Catawba grape, gathered June 2d:

| | |
|---|---|
| Potash, | 13.39 |
| Soda, | 9.69 |
| Lime, | 4.39 |
| Magnesia, | 1.74 |
| Phosphates, | 32.95 |
| Sulphuric acid, | 2.09 |
| Silica, | 29 65 |
| Chlorine, | 0.74 |
| Carbonic acid, | 3.05 |
| Ash of the wood, | 0.98 |

At this period of the year the leaf is rich in phosphates and alkalies. It is well known that bones and alkalies are among the best fertilizers for the vine.

§ 125. The ash of wood, it is shown, differs in the proportions of organic matters. They differ also, in quantity of carbon or charcoal the wood furnishes. Thus, beech wood gives 17.16 per cent. of charcoal. Deducting its ash, it leaves 16.94 as pure charcoal.

The iron wood gives 16.21. Deducting ash, it leaves 15.91. The broad leaved laurel gives only 7.30; and deducting ash, 6.60. The wood is very compact.

The chestnut gives 9.75; ash 9.27.

The white elm gives 15.84 per cent of coal, minus ash; leaves 15.04.

The black birch gives 16.01 charcoal, minus ash, equals 15.96.

The pear tree has 9.79 per cent. of coal, and the apple 15.90; abstracting the ash of the latter, it is reduced to 15.70.

From the foregoing, it appears that the quantity of carbon or coal which the hard woods furnish, rarely exceeds 17 per cent., and this is reduced by extracting the ash.

## CHAPTER XV.

Nitrogenous fertilizers most suitable for the cereals. Correlation of means and ends which meet in fertilizers. The final end of nitrogenous bodies. The power to store up or consume fertilizers modified by age, exercise and temperature. Error in cattle husbandry. Crops containing the largest amount of nutriment. Weights of crops, etc. Indian corn and turnips. Sweet potatoes. The produce of an acre of cabbage, etc. Cultivation of fruit trees—trimming and protection.

§ 126. As those substances are the most suitable for fertilizers, especially for the cereals, which contain the most nitrogen, so, those containing this element are the most suitable food for animals; and as none of the cereals can be grown without this element, so animals cannot be sustained unless it forms a part of their food. There is, therefore, a correlation of means and ends existing in the established order of things between what plants and animals require for sustenance. In the first case, it would seem that the nitrogenous compounds are secondary necessities, while in the latter they are primary, or have immediate reference to the characteristics of the class of beings by whom they are required. They are more essentially the force creating elements, and are designed to be expended for this purpose, and never to accumulate beyond the creation of the parts which are the seat of the force, while in the vegetable kingdom they accumulate and are not consumed in the performance of any of its functions. Gluten, a nitrogenous element, and starch, a heat producing element, accumulate in the grain. There they remain until on being received into the animal structure; the latter is expended in developing heat, the former in motion or exercise of the muscular organs.

§ 127. The final end, then, of furnishing nitrogenous bodies to growing vegetables, is to supply necessities which the nature and construction of animals demand; and herein is a broad distinction between the two kingdoms—accumulation in one, waste in the other, or a consumption of its own organs in animals, requiring therefore constant renewal to supply the place of the wasted tissues which have been expended in the development of force.

In the animal economy the heat producing bodies, *starch*, *gum*, *oil and sugar*, cannot be substituted for the flesh and force produc-

ing bodies, gluten, albumen and fibrin or casein; their functions being totally different. A dog cannot live on pure starch or sugar; neither could his life be sustained on pure fibrin. There is always a mixture of these bodies in all kinds of food as prepared by the organic bodies.

Wheat, Indian corn, rye, etc., have been shown to consist of a number of elements belonging to each of the class whose functions in the animal economy have been stated. Any of the cereals will sustain life, as they furnish both heat and flesh. Rice contains less of the flesh producing elements than wheat. Indian corn by itself is probably the best life sustaining body of this class.

§ 128. The ability or power of the animal machine to consume and store up elements is modified by exercise and age. The growing animal only accumulates as it is necessary; it is a law that the young should attain the size of the species; so in passing from the embryo to the adult state, consumption falls short of accumulation, when the adult state is attained accumulation is no longer necessary, and the amount of food taken has to be adjusted to the preservation of the balance between the food eaten and the forces which consume it. Exercise increases consumption, a fact established by numerous experiments made with healthy animals. This is an important consideration when applied to the fattening of animals. When they are allowed to run at large and exercise at will, or even subjected to such an amount of exercise as may be required to feed, the accumulation of fat is slower, and the quantity of food is less, which is necessary to reach that state of obesity required for the stall; a larger amount of food is necessarily consumed than is essential to it when the animal is still and performs no more exercise than health demands.

In illustration of the foregoing statement, it has been determined by experiment that where 20 sheep were allowed to run at large in an open field, they consumed 19 lbs. of turnips each day for 3 successive winter months; they gained during the time of trial 512 pounds. Twenty other sheep kept for the same time in a shed, and upon an average consumed 15 pounds of turnips per day, and increased in weight 790 pounds. In addition to the turnips both flocks were fed half a pound of linseed cake and half a pint of barley, but from inclination the enclosed flock consumed one-third less linseed cake than the out door flock. The increase in the confined flock was greater, and also the consumption of food less.

Protection from cold weather is another way of increasing weight by the use of less food. Those elements which are burnt in the system for the purpose of developing heat, must be provided in larger quantities and proportionate to the severity of the cold to which they are exposed. The starch, oil, sugar, etc., is consumed for the generation of heat, which would be deposited in fat if the medium in which they are placed were warmed or was protected from extreme severities.

The natural adjustment, then, of food to the wants of the system is influenced by age, exercise and temperature. The two latter may be controlled by means both simple and cheap, so that both food is saved and accumulations of fat deposited.

§ 129. The great error in this State in cattle husbandry is, the practice of compelling animals to shirk for themselves both winter and summer. So effectually do they consume all they eat in winter to keep themselves warm, that when spring comes they are more *than spring poor*, and two months is required to get them up to a living condition; and it is rare that a fat animal is found or made during summer and autumn.

There is, then, no doubt that shelter and food is required in North-Carolina as well as in New York, though the climate is much more favorable here for every purpose than in the north. The natural food which is mostly the produce of old fields and the wood and swamp ranges, is far less nutritious than the cultivated vegetables; more exercise is required to get it, and hence a greater amount of expenditure of force is necessary. This, coupled with the fact of a less nutritious food and exposure, accounts for the small size of the stock of the Southern States.

§ 130. It is an interesting enquiry, what crop or production contains in itself, the largest amount of nutriment or life-sustaining elements? In a question of this kind, it should be understood that it is not simply albumen or gluten, the flesh producing bodies, which are involved in the question, or the quantity of heat producing bodies as starch, sugar and gum; for neither class of bodies is in reality life sustaining by itself, but it relates to, or means to inquire, what crop per acre contains that combination of the heat and flesh producing bodies in the greatest quantity? A good old Malthusian would regard this as a question of the deepest import, and would call to his aid the power of arithmetic and of the statistics of crops to solve the question.

§ 131. To obtain a close approximate solution of this question, it is necessary to state the several weights of the crops which an acre yields under good culture. An acre should yield, for example, 25 bushels of wheat, though large territories may not yield more than 15 bushels; but an acre which will yield 25 bushels of wheat will yield 60 bushels of corn—it is always competent to do this; but the reverse of this is not true, for swamp lands will readily produce the Indian corn, but not more than half the amount of wheat and of a poor quality.

If Indian corn is compared with the turnip, which is regarded in England as furnishing the greatest amount of life preserving elements, it will appear that in this respect it exceeds our favorite crop. It is assumed that a crop of turnips yield per acre 67,000 pounds, but only one-ninth of this is nutriment, the rest is water; there is, therefore, out of the 67,000 pounds only 8,444 of dry matter. The heat producing elements only equal 6,220 pounds, and the flesh producing bodies amount to 1,000 pounds. The grain of Indian corn contains in an acre 2,780 pounds of starch, oil, &c., which belong to the heat producing bodies, while the flesh producing amount to 840 pounds. If the grain only is taken into the account, turnips rank higher than corn in their life sustaining power. But it may thus be that though turnips outweigh Indian corn, it is not clear that in actual service this crop could by itself be employed for the human family; it answers a good purpose as one of our dishes, and gives a relish to a turkey or roast beef; no one would like the process of being fattened exclusively upon turnips. But Indian corn being susceptible of all kinds of treatment by the cook, each one of which is generally relished, it is highly probable that it should be placed highest in the scale as a life sustaining body.

§ 132. Of the root crops, though turnips in England are preferred to all others for fattening cattle, yet they must rank far below the sweet potatoe. The dry matter in the sweet potatoe amounts to 30 per cent. It contains 19 per cent. of starch, 5 per cent. of sugar, and nearly 1 per cent. of dextrine or gum. Its heat producing bodies in the aggregate amount to 25 per cent. at least. It contains nearly 7 per cent. of flesh forming bodies. A crop of sweet potatoes will weigh per acre about 30,000 pounds. The quantity of starch, sugar, &c., will amount to 7,625 pounds, and

the weight of the flesh producing elements amount to 2,100 pounds. The life sustaining elements, therefore, in the sweet potatoes exceed those of the turnip, and would be preferred by far to them; and if the human family was reduced to the alternative of subsisting upon a single product, the sweet potatoe would do, because, like Indian corn, it may be cooked in various modes and made to suit the palate, which is by no means to be lost sight of. But the turnip has too much water, is too insipid for daily use by itself, and could not be employed alone as a life sustaining substance, notwithstanding its rank. It takes rank because of the immense weight of a crop upon an acre. Taken pound for pound and it ranks low in the scale of nutrients. A person would have to consume 3 pounds of turnips to obtain the nutrient matter of one pound of the sweet potatoe, if our estimate is founded upon the quantity of dry matter which they respectively contain. In the Indian corn there is about 14 per cent. water; by the most thorough drying it amounts to 16. The remainder is important as a nutrient, taking the word in its broadest signification.

We are aware that Johnson's doctrine is somewhat different. He maintains in his scale of heat producing elements that the turnip will support eight times as many men upon the same acre as wheat. On the other hand, when they are estimated for flesh forming qualities, turnips will support four times as many men as wheat, Indian corn, or barley.

Cabbage, however, it is admitted, ranks higher than turnips in its flesh forming elements. The Irish and the negro population seem to understand this; the former particularly, purchase in market a cabbage, if it is to be found.

§ 133. The produce of an acre of cabbage amounts to 24.2 tons if their heads average 10 pounds each. Of this quantity 20.2 tons is water and 4 is dry cabbage, of which a ton will contain 324 pounds of nitrogenous matter. A ton contains 18 pounds of inorganic matter, but if the substance is perfectly dry, it contains 153.9 pounds. The problem to be solved, however, is not the power of the different kinds of substances to sustain life by their actual amounts of heat or flesh producing elements which they contain. It does not seem to be intended that either man or beast should subsist upon one kind of food. The appetite is never satisfied with one or two things even,—it seeks variety; and when variety is at-

tainable, the strength for labor and the enjoyment of health attains its maximum power.

Turnips and cabbage are important articles in the list of nutriments; and although they may contain more nitrogenous matter than wheat or corn, yet few persons would make them their exclusive meat and drink, unless driven by necessity so to do; and if necessity compelled men to take them, the power to work and endure fatigue would be diminished, while Indian corn, wheat, or even sweet potatoes, though they contain less nitrogenous matter, would supply the wants of the system much better.

§ 134. It is maintained, and the fact should be noticed in this connexion, that root crops, particularly the turnip, are to be specially recommended for cultivation as they impoverish the land less. Let us look, however, at the facts. A good turnip crop weighs to the acre 67,000 pounds, and its inorganic matter or salts amount to 450 pounds to the acre, while wheat has only about 60 pounds in the 25 bushels. Cabbage takes away about 600 according to Johnson, but this is rather to little for dry cabbage; it amounts to 615.34 pounds. Green cabbage contains only 18 pounds to the ton. When we consider, then, the great weight of a good crop of turnips or cabbage, it will be admitted, we believe, that they are really more exhausting than the cereals. It makes no difference in the final results if it is proved that the root crop derive a large share of their nutriment from them; they must obtain inorganic matter from the soil in due proportion, and experiment proves that they remove more from the soil than other crops. This is not stated with a view to discourage the raising of roots. They have their place in feeding animals in the winter and spring when the green grasses cannot be had. But they should not be selected for cultivation on the erroneous doctrine that they do not impoverish the soil, or to less amount than the cereals and many other crops.

§ 135. Our remarks thus far have related to the cereals and those crops which are designed for the sustenance of man, or rather the character of the elements which he constantly employs.

We have another class of nutrients in fruits, which are of vast importance. Their cultivation is every where, we may say, receiving special attention, but many work on the old doctrine that a fruit tree or vine will provide for itself, if it is once fairly planted and watered a few times. It lives and may be it flourishes a few years,

but in process of time it ceases to grow, and its fruit fails in quantity and quality. In such a result the planter is very apt to say that the climate is unsuitable for its growth.

But let us briefly inculcate the true doctrine relative to trees. They require fertilizers as well as the cereals, and most of the fruits are injured by heavy grass culture, and especially by corn. The reason is they are robbed of food. Roots extend much farther than many suppose; hence the deep plowing at a distance from the trunk breaks up the rootlets and cuts off the channels through which nutriment ordinarily flows. Thrifty and profitable trees are made in this way only, that of supplying that variety of nutriment which any farmer knows his wheat or corn requires. The mode which should be followed in applying it, is to broadcast it over the surface, and which should extend beyond the shade of the branches. Very few rootlets for the support of the tree are thrown out, ordinarily, near the trunk. It is of little use again to trench around the tree and deposit in the cut manure—it is far better to give the whole surface of an orchard dressings of composted manure. Such a course favors the development of rootlets, and the nutrient matter is carried down to them in that dilute condition which their spongioles require; and lastly, trees require clean culture, the removal of all weeds beneath, and suckers which sprout from the base of the trunk.

§ 136. Many trim their trees outrageously by cutting the lowest large branches; the consequence is the production of a high, slimheaded tree of little value. The growth of the apple tree is upperward and narrow, with only a slight tendency to spread or expand latterally. This mode of trimming the tree increases the upward growth, and hence, a very imperfect head is formed by the lateral extension of the side branches. Trees thus mutilated always remain *cripples*, if the word can be applied to trees. Even peach trees in North-Carolina are deprived of their best bearing branches. In addition to the injury sustained directly as fruit-bearing trees, their trunks are also exposed to the heat of the sun, which blasts the south or south-western sides, in consequence of being deprived in part, at least, of the shading which they require from the branches.

In regard to vines, we believe the European mode of close trimming not well adapted to the cultivation of our native graves. It

is unnatural, and not really required by our climate. It is true, the Catawba, under the knife and shears of foreign culturists, have survived thus far their mutilations; but this fact rather proves *their life tenacity* and natural recuperative powers under injury, than the utility of the practice. What the human system may endure under physic is one thing; what it requires, and is necessary for perfect health and developement, is another.

In our southern climate, protection from a burning sun on the side exposed from noon till five, is one of the most important points to be attended to, and probably it is equally necessary in the growth of young orchards and vineries to protect the roots during the heat and drouth of summer by *mulching*. The object is to preserve the water of the soil, or prevent its excessive evaporation by organic matters, which are the most retentive of moisture of all bodies which can be employed for this purpose.

NORTH-CAROLINA GEOLOGICAL SURVEY,

PART II.

# AGRICULTURE.

CONTAINING DESCRIPTIONS, WITH MANY ANALYSES, OF THE SOILS OF THE SWAMP LANDS.

BY
EBENEZER EMMONS,
STATE GEOLOGIST.

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# PREFACE.

THE Swamp lands of North Carolina seemed to require a special examination in consequence of their variable characters and their great extent of surface. Differing in all respects from the uplands, but possessing among themselves certain characters in common, and at the same time as bodies of land other characters, which are not common, we have entertained the opinion that they richly deserved a careful examination, and have been encouraged to undertake it in the hope that it would result in the discovery of many important facts. Such a result has been hoped for by the fact that other State surveys, as well as those which have been undertaken by private enterprise, have left this field untouched.

Viewing the subject in its most general points, before the work was undertaken, it seemed that the most important questions requiring solution were those which related to the condition and state of the elements which compose these soils, their relative and absolute quantities, and their prospective powers of endurance when brought into cultivation; the latter of which would be determined, or at least indicated, by the per centages which analyses would give. These are some of the views which have governed us in the choice of measures we adopted in executing the task, and which have also incited us to the undertaking. As we had already determined from several analyses that there were varieties of soil included under the general term *swamp lands*, though they have the same aspect and appear much alike, and yet were found to be unlike the best lands under this class; so we felt that it was important to be able to point out those particulars in which they differed. This is not at all difficult when subjected to laboratory tests, but it would be still more useful to point out some method which could be executed by the planter, and upon which he could rely, at least so far as to distinguish thereby the poor soils from the rich.

The method proposed is simply a mechanical separation of parts by means of water, and by which the coarse sands may be obtained separately from the fine, the latter of which are really the important inorganic parts, and which give in analysis the lime, iron, alumina, phosphates, magnesia, etc. These complex elements, which furnish these important nutritive or available elements differ in different localities and in different parts of the same tracts, facts which are explained in the text. In some they are reduced to 2.50, or 3 to 4 per cent., when in other parts perhaps of the same tract they exist in proportions varying from 10 to 50 per cent.

By a mechanical separation in the mode we have described, a planter may determine these important facts for himself with sufficient accuracy to guide him in his purposes, for it is an established principle, that when the inorganic matter does not exceed 3, 4, or 5 per cent., the land will not produce well. If, however, this small per centage exists only in a top layer, and at a depth of 18 inches or so, there is a stratum charged with a larger per centage, say 10 to 15 per cent. of inorganic matter in which the fine soil exists, the land may be cultivated successfully; if, however, a stratum of this kind is 5 or 6 feet below, or we have a mass of this thickness composed almost exclusively of vegetable matter, the plant will be unable to send its roots thus far, for it will perish too soon to secure a foothold on life, just as it would in a bed of marl, or a heap of stable refuse.

The Carteret county open prairie has been re-examined, and we find a more favorable composition of its soil than at a previous visit. Drainage of a tract has effected a shrinkage of the vegetable matter so much that a stratum of soil may be reached by the roots of crops. The tract, in its poorest constitution, is by no means to be ranked with a first class swamp soil. I have stated that there is a belt of excellent land surrounding the open prairie. But though the open prairie is not well adapted to the growth of the cereals, yet for Irish potatoes it is admirably constituted, and it is not improbable but that an enterprising man would make money by their cultivation. But I have stated the principal facts in their proper places, and need only refer to them in this place.

The labor required in the analysis of so many specimens has been exceedingly great. The work has been in hand more than two years. My assistants have been employed with me in the work

when in town and when out door work was impossible or could not be prosecuted to advantage. We have no doubt that much more should be undertaken, the results of which would be anvantageous to the State, at least indirectly. It is highly important that lands so fertile should be brought into cultivation, and we have no doubt that large tracts which are classified under the term, *swamp lands*, are to become the best in the State for the growth of cotton. The great want which is felt is the construction of roads by which these lands may be reached and brought into market. We have no hesitation in saying that the two millions of acres of swamp lands are worth four millions of upland. In a rough estimate of this kind, we take *time and expense* of cultivation into the account—the time these lands endure without the use of expensive fertilizers, and the ease and the slight wear and tear of the instruments used in cultivation, when compared in the same list of expenses required in the cultivation of the uplands of the middle counties.

However this may be, our aim has been to place the merits of these lands in their true light; not to exaggerate or depreciate. If this aim has been secured we shall be satisfied with the results.

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# SURVEY OF NORTH-CAROLINA.

## PART II.

# AGRICULTURE.

May, 1860. E. Emmons.

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## CHAPTER I.

The compensations which take place in nature and by which a balance of forces is preserved. Considerations relating to water. Water surfaces. Evaporation regulated by saline matters in the ocean. Carbon and carbonic acid. Insolubility of vegetable matter a conservative condition. Average fall of rain.

§ 1. Rational farming rests on compensations, and has to be conducted in accordance with the known laws of nature. If, in any part of space the balance of the forces is about to be lost, there will immediately set in counteracting forces to restore the balance which is thus endangered. The machinery of nature is so constructed, or under the government of such forces, that a balance is preserved among them. Heat rarefies the air, and it rises in space, but its place is immediately supplied from the surrounding cooler atmosphere. The great body of it may be moved over extensive areas, and when it has been subjected to excessive heat, the balance must be restored by winds and forces acting with a violence proportioned to the causes of disturbance. The evaporation of water from the soil is in part, and for a time, restored from the reservoir below. When, however, solid matters are removed from the soil by cultivation, the balance can be restored only by the hand of man. Even water has to be provided in certain countries by irrigation. But in the general operations of the natural forces, ample provision is made for supplying water, ammonia and carbonic acid to all parts of the earth's surface. If no provisions existed in the

machinery of nature to effect a general distribution of these important elements, the earth's surface would be a barren waste. Irrigation can only supply water under favorable circumstances. The great reservoirs of water for watering the earth are the oceans. Let us see how the machinery works when it is furnishing the supplies which vegetation every where requires. In the first place, it is necessary to know that the area which is to be watered must be rightly proportioned to that from which the supply is to come, and this supply is derived from the water surfaces provided for the purpose. Now, the Atlantic ocean has an area of twenty-five millions of square miles, and the Pacific of seventy millions. These are the two great water surfaces upon which an earths surface of thirty-five millions of square miles is dependant for a constant supply of this element. Now, it is a necessary part of the arrangement, that water should pass from the state of water to a light vapor, at all temperatures. Water has this property, though we connect its vaporous state with its boiling condition, when its temperature is raised to 212° of Fah. But at this temperature we find that the heat it receives is just balanced by its apparent loss or by latent heat in the vapor as it escapes. While heating up to 212° its accession of heat is greater than the loss locked up in vapor, and hence, continues to accumulate, or to grow hotter, till it reaches this point. If vapor was not formed till water boiled, or indeed, if not formed at all temperatures, the earth would be uninhabitable.

Water then exposed to the atmosphere at all temperatures gets sufficient heat to change it into vapor. It is water still, but its particles are so widely separated by heat or expanded that if seen, it is a *mist*, a *cloud*, or *may be steam*. Its expansion lifts it above the water surface, but this is not all; the heat which has thus generated vapor, creates also currents, moving air, or wind; and wind is the transporting agent by which vapor is borne landward. It sweeps over vast areas, reaches the mountain ranges, and upon every object, tree, stone or land, which is cooler than the vapor itself, it deposits a part of its burthen. This is especially the case as it sweeps up the mountain side, if it is tall and reaches the region of frost, it is entirely disburthened of its load. It is here, however, where streams and rivers are formed and from whence they flow seaward, carrying back to the parent bosom every atom which

the sea had loaned. Should but a few atoms be lost in the outward or homeward journeys, the sea would fail to be kept full, and in process of time it would be dried up. Every atom is therefore sent back, and thereby the balance of nature is preserved. Water endowed as it is, must circulate and supply the earth, and its people with itself. A counteracting law would be required to arrest its service. Our safety, however, for a supply rests mainly on the ease with which the loaded winds discharge their cargoes. If they were more niggardly, and held on to their possession with a miserly grasp, the poor plains and rolling hills would be swindled out of their dues; and none but the snow clad mountain could extract the liquid treasure.

Nature then has provided a machinery for the distribution of water which works perfectly. The farmer may sit in his parlor and see its operations. He needs no watering cart to supply his crops like those used to lay the dust of the streets of cities. Such would be too expensive and cumbersome and would utterly fail. Compensation is the law. If the mountains, hills, and plains are irrigated by the forces of nature, ample provision is made for the return of the element to its parent bosom to be re-used and so work on as long as seed time and harvests shall continue. Now water how many times soever it takes its round of circulation never wears out, and it has been found, that a given area of land gets punctually its annual share; and those countries which are deprived of rains or water in its usual form, ever remain in this condition. This stability is due to the uniformities in the operation of forces. The winds, unstable proverbially, are still under the government of law, and hence, as carriers of rain, and distributors of the elements essential to the growth of plants, perform their offices so punctually and regularly that the kingdoms of nature rarely suffer from their failure to perform their office. But it seems to us at the first thought, that as three-fourths of the world has to be laid under water so that the other fourth may be supplied with this element that nature has been too lavish in its supply of evaporating surfaces. We are however, forced to admit the fact after we have found that it is rare that it is any where in excess. It is true that a few limited patches of land in India, where according to observations not less than 600 inches of rain fail during the year, a quantity which if furnished at one time would cover the country with a

depth of 50 feet. Here there appears to be be a great excess of this element. As an offset however, to such excessive installments of rain, we have several rainless districts, as Peru, Chili and the Sahara of Africa, and hence it is probable that the average quantity of rain for the whole acreage of land, would scarcely exceed 50 inches; and hence, in the general operations of nature, there is only a sufficient water surface to supply the rains which are necessary to the vegetable and animal kingdoms.

The annual fall of rain at Chapel Hill is 43.96 inches. At Gaston 40.83 inches, and at Murfreesborough 32.54 inches. There is no excess of rain it would seem from the few observations to which we can gain access in the Eastern counties.

We have said that all the water which the Oceans loaned from their exchequers is returned in due time, not, it is true, in the same individual particles, for the Atlantic furnishes water to the Pacific, and there is no doubt a mutual interchange, but each gets its quota and thereby keeps its coffers filled.

But rivers, though they return all the water required, they do not return it in the pure, unsophisticated state it was when it set out on its journey borne by winds to the mountains. On its return it is burthened with salts of various kinds. It robs the soil every where of its matter which we call fertilizing. Is it a trespass upon the plantation through which the rivulet flows, a robery of which the farmer has a right to complain? In general, it is not. In a few particulars it may be. We think the Roanoke should cease plundering the upper country, but in general, we may say, it is a necessary tithe to the parent waters. It is necessary to enable these great bodies of waters to fulfil their functions to earth and man, to the kingdoms of nature.

According to Maury, the Philosopher of the Sea, these saline matters serve to keep the sea in motion; they bring particles at the top losing their proportion of fresh water, become more saline and heavier, and sink to be replaced by particles moving upwards. But when the evaporating forces act upon large surfaces under a vertical sun, the excess of fresh water removed is so great that a dimple in the surface of the sea is formed whereby the outer boundaries rush in to fill up the excavation. But saline matter in the sea retards evaporation; it becomes a check upon Eolus or any wind which would perhaps take too much at a time, and thereby

unnecessarily drench a part of the earth. Saline matter, therefore, checks evaporation, and as fresh water floats upon the surface and may be evaporates rapidly for a time, the process will be interrupted when a more saline layer is reached; moderation is thereby secured.

§ 2. But it may be inquired, what consequences are likely to follow from a constant access of saline matter in the ocean? Will it become surcharged by evaporation, and will it become too saline for terrestial vegetation? Such would be the case were it not that the forces of nature tend here as elsewhere to balance each other. The sea is like a great peopled city. There are builders there who want matter for their habitations. There is the coral insect who builds reefs extending for a thousand miles in a continuous line; there are oysters, clams, and myriads of shell fish as they are called, who use vast quantities of lime and other materials. We have seen that the great depths of the sea are sanded with minute shells of foraminifera. All these builders conspire to keep the sea well balanced and cleared of excess of saline matter, and there will be no excess, because it is solidified by the organisms prepared for the purpose; and such has been the operations of life, in all past time; the older rocks are charged with marine organisms, and the newer are equally so, and it is in this way the planter is provided with marl and other fertilizers, deposited where the sea once stood. He now reaps the benefits of the saline matter which was robbed from the land millions of years ago. It is now returned back for his use in a better form and state. But the salt of the sea would form a huge pile if gathered into one heap. Shafhautl has computed, that the mineral matter suspended in the ocean, is equal to twice the bulk of the Himalayas. It is even said that there is common salt enough in the ocean, to cover an area of seven millions of square miles to the depth of one mile. We have reason to believe this immense amount of saline matter has been taken from the land since rivers have flowed seaward, though it is not fully settled, neither can it be; whether the ocean was created brackish, or was originally fresh water like our rivers, the *operations* of nature have not fully declared either in the affirmative or negative.

§ 3. The swamp lands of North-Carolina and of the Atlantic coast, contain a vast amount of carbon. The vegetable matter is

often more than 10 feet deep; and sometimes it is not easily sounded by the longest poles we can use. The quantity of organic matter, mostly carbon in some form, varies from one-half to ninety-five hundreths of the dry mass.

Whence has this vast quantity of carbon been derived? Now the answer to this question does not appear to be difficult. In the first place all of it was once alive, and it all consists of the remains of vegetables whose constituent element is carbon. Now the foundation of this carbonaceous body generally rests on a pure sand, or a mixture of sand and clay; in a great measure is entirely destitute of carbon or vegetable matter, and hence we may assume that the original soil did not contain this element and could not supply it. We are, therefore, obliged to look for a supply to the atmosphere as has already been indicated in a former treatise. It may be interesting to see the computations which have been made with respect to the quantity of carbon in the atmosphere in combination with oxygen, forming carbonic acid. Thus the whole weight of the atmosphere being known, it has been determined with great accuracy that its carbonic acid forms one thousandth of this weight, and as carbonic acid contains twenty-seven per cent. of carbon, the atmosphere will contain three thousand and eighty-five billion pounds of carbon. This quantity, it is maintained, exceeds all that is locked up in the forests, and in the condition of mineral coal in the earth's strata. From these facts we may be satisfied that the air can furnish carbon to an unlimited amount. It might appear that the withdrawal of this vast qauntity of carbon from the atmosphere would materially affect its composition. Of this we cannot be assured. The withdrawal is a fact, but the sources of supplies are adequate to effect a replacement of the abstracted carbon. Thus in volcanic action vast qantities of carbonic acid pass into and mingle with the atmosphere. What is withdrawn by the operation of one class of forces is replaced by another, so that it will be found, that the true balance is preserved, that which organized beings, by their constitution require.

In the coal period vast quantities of carbon were withdrawn also from the atmosphere, and solidified in the anthracites and bituminous coals; and hence it has been said that this abstraction of carbon rendered the atmosphere better and purer than it had been in former periods. The carbonic acid in the concurrent changes

of the day, gave up its oxygen, which, being added to the atmospheric mass, improved it to the amount thus added.

Whether the constitution of the atmosphere has changed materially since animals and plants were created, cannot be settled by calculations of the foregoing kind. We must resort to the determination by facts of a different nature—those which relate to the wants and necessities of organic bodies. If our observations on animals and plants are extended to the coal period, we cannot find that they differed in their capacities to resist the poisonous effects of excessive doses of carbonic acid better than those of the present time. They appear to have been fitted to precisely similar conditions of the surrounding elements, and to have breathed an atmosphere like our own, and to have inhabited a medium identical with the waters now upon the earth's surface. In fine, it is not proved satisfactorily that the deviations in the composition of the controlling elements would injuriously affect the living organisms of the present period. So that to all intents and purposes the atmosphere was composed of elements existing in the ratios that they now exist. It is possible, however, that compensating forces were more active in early periods than now. If carbonic acid was removed more rapidly from the atmosphere in the coal period, it may well be maintained that volcanic agencies may have liberated more carbonic acid from the interior of the earth than now, and hence, a balance among the forces would be preserved.

§ 4. The vast body of carbon locked up in the swamp lands of North-Carolina must have been in solution, otherwise it could not have been received into the tissues of the plants. As it now exists it can scarcely be regarded as a soluble substance. If its solubility had been preserved it would have disappeared and found its way to the ocean. Insolubility is a preservative force, intended to protect important bodies from waste. The property, however, is excessively strong; as humic acid resists water alone with considerable force, requiring 2,500 times its weight to dissolve it. Both heat and frosts too affect its solubility; both enables it to resist solution. In these facts we find a preservative power by which vegetable fertilizers remain a long time unchanged.

§ 5. While the carbonaceous bodies are soluble with difficulty in water alone, we find that alkalies and particularly ammonia effect their solution, and it seems that they have a strong affinity for this

substance, absorbing it readily wherever it is in their reach. As ammonia is present in the atmosphere, and as rain contains it in small quantities and being carried down into the midst of the peat, it dissolves or combines with portions of it, and forms thereby food for the nourishment of plants. While then, water in which peat is constantly immersed scarcely dissolves it, ammonia comes in aid of its feeble solvent powers, and thereby prepares a nutriment for the growing crop; but the great store of matter remains, and is only prepared in divided doses. The conservative force exerted in solution, is not probably all that is concerned in supply, it is not improbable that the vitality of the plant some way or other regulates and controls the reception of nutriment. We are not prepared to say how. It may be ultimately worked out by successive discoveries similar to those which took place in regard to the changes effected by the plant upon carbonic acid.

It would then be like the history of all great discoveries, effected at different times and by the sagacity of different persons. Thus, Bonnet, first observed the evolution of a gas from leaves immersed in water; Priestly, discovered that that gas was oxygen; Ingenhouse demonstrated the necessity of solar light for its disengagement, and finally, to complete the range of discovery, Lenwestein has the honor of showing that the gas oxygen, is derived from carbonic acid. It is thus that discoveries advance in a certain line, step by step towards an ultimate fact, or generalization, which is required in order to express the perfection of the advancing series. It is only at the termination of such demonstrative truths, that theory receives its finishing stroke. In agriculture, practice has no doubt advanced farther than theory. Indeed theory is so far in the back ground that it may be regarded as existing in expectation, rather than in fact. The advancement of agriculture then, cannot be ascribed strictly and in truth to theory; neither has it been so much under its guidance as many of the sciences. Many practical suggestions have sprung up from theoretical doctrines; still, the practice of agriculture is rarely governed by them. Indeed agricultural theories, belong to the, *a posteriori class*, or those which have grown out of experience. That the practice of agriculture has advanced far towards perfection without the aid of theory, is not surprising, when it is considered that its operations are very simple, and that results flow from them with great cer-

tainty. This fact has prevented that special consideration of phenomena, which would have come to pass in more complicated arrangements. Besides, the phenomena with which agriculturalists are most familiar, are enveloped in a kind of mystery; and hence, appear to be beyond their reach. They can however, bring out the phenomena of vegetation in its season; the grass and grain spring up when they sow the seed; they grow up under their eyes, though not in obedience to their will. They stand however, in the place of its proximate cause and they have learned by ample experience, that their growth may be promoted or retarded by certain agents; yet, the why and the wherefore they have not satisfactorily determined.

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## CHAPTER II.

The UTILITY resulting from the analysis of soils. Methods pursued.

§ 6. A change of opinion has undoubtedly taken place in the minds of farmers and chemists respecting the advantages of soil analyses. In the earliest days of agricultural chemistry expectations were no doubt too high; too much was expected. It would, however, be contrary to facts, to deny that agriculture has been advanced by the analysis of soils and the ash of plants. The knowledge of soils is certainly much more exact than it could have been had their composition been left to conjecture; and it is certain that farmers do proceed in the application of manures with better and more distinct ideas of what they are doing and what they want. They now know the reason why the expensive manures, potash and the phosphates, need be applied.

§ 7. It is no legitimate argument against analysis because it has not accomplished all the utility which may have been claimed when systematic agriculture was younger. If farmers and chemists will only look at results, or study the history of agriculture for the last fifty years, they will feel satisfied that its advancement has

been due in the main to chemistry, and in part to the direct results of the analysis of soils. Indeed, no real or rational progress could have been made until much had been done in this line of chemical research. The importance of minute proportions of the alkalies, alkaline earths and phosphates could never have been understood without these analyses. Experiments too, have grown out of chemical results of the highest importance. The use of organic matter has been established by experiments suggested by analysis. It has been proved that organic matter is equally important with inorganic, and moreover, must exist, or be furnished and exist in it in a certain condition. No soil is absolutely destitute of organic matter, but in the South its proportion is often too small. Planters in the Southern States now understand why marl is injurious in certain cases. They know how to prepare it for use to avoid disastrous results; and all this must be traced to the benefit of the analysis of soils. Show the planter a field which is deficient in organic matter, and his application of marl will be governed by this fact. He knows that if a large dressing is applied, his objects will be defeated. He will proceed and make a compost of organic matter and marl; and he knows that thus prepared, he may use marl freely on poor land.

Now, accident could not have put him in possession of this important practical precept. He would, and did find out, that heavy dressings of marl were injurious to crops for one or more years; but he would never have discovered that it was due to a deficiency of organic matter. This main fact was determined by analysis, and moreover, it led to the settlement of the question respecting the condition of the matter itself, and it is well established that it is necessary that it should be oxidized, and pass to the condition of an acid, in which state, it combines with the alkalies and earths, and forms soluble bodies. These organic salts become the food of the crop. The fact then, that organic matter is indispensable to a fertile soil, together with the reason why, has grown out of analysis. But this is only one result. It may be said generally, that all the most important experiments in the growth of crops have grown out of the analysis of soils. For example, it was found that the phosphates and alkalies formed only small fractions of all, even fertile soils, and it occurred as it naturally would to philosophical minds whether such small doses were really necessary to

the ripening and perfection of a crop. Experiments to settle this important and interesting question were set on foot to determine it, and they have resulted in showing clearly and satisfactorily that however little they may be, they are still essential to the perfection of seed. Now, what has grown out of analyses must be regarded as it respects utility, as a part and parcel of the original investigation, and analysis thus viewed cannot be regarded in other light than as having been eminently useful. It was necessary that it should precede and prepare the way for this experimental work, and we may probably assume that unless the preparatory steps had been taken, those important questions would not have been propounded.

The great objection which has been made to the utility of analysis is that chemistry is incompetent to detect the certain minute and essential elements of soils, without which the plant cannot perfect itself, may exist in the soil in sufficient quantities, and yet be beyond the reach of the chemist's skill to detect them.

Chemical analysis for example pretends not to find a less fraction than $\frac{1}{1000}$ of a grain; an acre of soil one foot deep will weigh 2,000,000 pounds; an ordinary wheat crop will take off 200 pounds of mineral matter, allowing one half to be phosphates and we have only one twenty thousandth part composed of that part or quantity; and hence, too small for the chemist to find. Four hundred pounds of guano, conaining say one-fifth phosphates applied to an acre entirely destitute of phosphates, would, it is claimed make all the difference there is between a good crop and no crop at all; but this eighty pounds, distributed through (2,000,000) two million pounds of soil would be too trifling a quantity for the present state of chemical analysis to detect. Besides, it is farther said he does not need it, it being too expensive and the general deductions of the chemist are of more value to him than any particular analysis of his soil. Granted; but then, these very deductions are either the results of analysis, or of experiments which analyses have suggested and called for. There can be nothing truer, and hence to discard analysis on the grounds stated is unjust to Liebig, Johnson, Mulder and others. Then again it is said that a Boston chemist found a barren sand of New Hampshire, with the same composition as another specimen from the rich Sciota Valley. This we doubt; be that as it may, the subsequent paragraph shows very distinctly the prominent differ-

ences of the two examples of soil. The New Hampshire barren sand was extremely coarse, the Sciota Valley soil on the contrary extremely fine. No one denies the importance of texture in a soil and the chemist who should neglect to state the differences between two so much alike in the quantity of sand, would omit a very important piece of information. It would belong to a series of general deductions which the chemist has formed from either his chemical and mechanical analyses of soils.

Again, the statement that one-fifth of the four hundred pounds of guano, consisting of phosphates distributed through 2,000,000 pounds of soil, makes all the difference between a good crop and no crop at all, is an assumption. In the case of the application of guano, it is only fair to assume that the 400 pounds added is just so much addition to the fertilizing matter already in the soil, and in most cases we have never found an exception to this result, that phosphates may be detected in 1000 grains of any soil. We are unbelievers in the doctrine that 80 pounds of phosphates only in 2,000,000 pounds of soil would produce a crop of wheat or any other crop; that it will, however, or will not, requires to be tested by experiment.

§ 8. The correct analysis of a soil is by no means a short and easy task, as many have supposed, or seem to suppose, when they forward their packages to the laboratory, and seem to expect replies within twenty-four hours, at least.

That the reader may entertain more rational views of the work than is usually expressed by our correspondents, we give in part the remarks upon this subject, by Dr. C. T. Jackson, of Boston.*

"The analysis of soils is so difficult, and requires so much time, that the chemist is often discouraged, and if paid for by the planter, it would cost more than he could well afford. Hence, trustworthy analyses must be made at the public expense, under the direction of government. The manner in which the present analyses have been made, demands from twenty to twenty-five days, and no chemist can properly attend to more than one analysis at a time. I state this to correct erroneous impresslons on the subject. In determining the ingredients of a soil, we have to work on a great

* Patent office report for 1858—pp. 291, 293.

number of its separate portions, sometimes employing 100 grains in the analysis, and at others 25, while to separate those ingredients which occur sparingly, we employ at least 1,000 grains for each determination. The results are subsequently reduced to per centage in the tabulated form. In the first place, the sample has to be dried at a moderate temperature in a current of dry, warm air, and then thoroughly mingled, so that the successive portions taken for analytic processes may be exactly alike.

To determine the amount of organic matter, 100 grains dried at 212° Fah. are burned in a platinum crucible, when the loss by combustion and volatilization is ascertained by decrease of weight. Then the soil is digested with chlorohydric acid, the matters soluble in the acid are ascertained by the usual method, and their proportions stated. Another analysis of 25 grains is next taken for analysis by entire solution, and this is decomposed by fusion with carbonate of soda in the manner employed in the analysis of insoluble silicious minerals, and a complete analysis made, all the ingredients being weighed excepting the alkalies, which are determined by difference, while their relative proportions are ascertained by the analysis of 100 grains of the soil by acids, and then their ratios are computed for that portion which had been analyzed by fusion with soda.

Again, separate portions of 100 grains each are employed for the determination of the proportions of carbonic and phosphoric acids, the first being ascertained by expelling, by means of a stronger mineral acid, in a proper aparatus. The phosphoric acid is thrown down from an acid solution in combination with peroxide of iron, lime and magnesia, all of which are precipitated by ammonia. The weight of these substances combined is first ascertained, when they are all re-dissolved and the oxide of iron is separated in a state of sulphide of iron, which is again converted into peroxide of iron by nitric acid, and re-precipitated, and again weighed, whereby the proportion of phosphates is ascertained. This is again checked by analysis of the sulphide of ammonia and solution of the phosphates.

Then for the determination of sulphuric acid, chlorine, nitric acid, ammonia and the organic acids, we operate on separate lots of soil, each weighing 1,000 grains. Sulphuric acid is precipitated by means of nitrate of barytes; chlorine by nitrate of silver; nitric

acid is tested in an aqueous solution of the soil, boiling it with chlorohydric acid and gold foil, to see if it dissolves any gold, and by evaporation of the aqueous solution to dryness, and by testing the deflagration of the dry residne which contains organic matters mixed sometimes with a minute proportion of nitrate of potash. There is no direct mode of determining the proportion of nitric acid in a soil. It occurs only in minute proportions.

The organic acids of the soil, crenic, apocrenic and humic acids are separated together from the insoluble humus by means of a saturated solution of carbonate of ammonia, and after filtration this solution on evaporation to dryness will give the weight of these acids, with some phosphates, which are always dissolved by the ammoniacal solution, namely, the phosphates of lime and magnesia.

On burning the organic acids these phosphates are obtained, and their weight deducted from the combined weight of the organic matters and phosphates. By deducting the weight of the soluble organic acids from the whole weight of the organic matters, we have that of the insoluble humus or carbonaceous matters. We also deduct from the soluble organic acids the weight of the ammonia and determine it by a separate process on another 1,000 grains of soil. The ammonia is ascertained by digesting distilled water, acidulated with pure hydrochloric acid with 1,000 grains of the soil; then on filtration, evaporation of the acid aqueous solution, and the addition of bi chloride of platinum solntion, we obtain ammonia, as a soluble chloride of platinum and ammonia, by which it is easy to compute the proportion of ammonia in the organic matter of the soil from the weight of the double chloride."

We have pursued for the most part the foregoing detailed methods, the results of which are usually satisfactory. Probably the analysis of the soil of the swamp lands will be attended with more utility than those of the midland or mountain counties, for it determines with certainty the fact whether they are susceptible of cultivation or not, and also, it determines the cause of their worthlessness.

Furthermore, as it regards the utility of analysis, we believe that they have promoted the advancement of agriculture in an eminent degree, and the reason why agriculturists and certain chemists decry their utility is owing to their not effecting what enthusiasts

promised, or what was expected. Too high expectations when unfulfilled are very liable to produce a reactive feeling and to call out sentiments entirely of a depreciating character, or to lead persons to say that they are of no account. But until thorough analyses had been executed, a correct view of soils, either practical or theoretical, could never have been obtained. We now know for a certainty, some of the functions of a soil, and it is a great deal to know that the most important elements of growth exist only in minute quantities, and that they may be removed in the course of a few years' cultivation. This is a practical fact, and could not have been guessed out; it remained to be determined by the skill of the chemist and accurately conducted experiments.

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## CHAPTER III.

The swamp lands. Their mode of formation and geological age.

§ 9. It is maintained that soils are the debris of rocks which have been forming from the earliest periods of the earth's history. This is no doubt literally true; but the debris has been subjected to certain changes, particularly those of place. It has not lain by the side of the rock from which it was separated in but few instances, but its removal or change of place has been excessive in many instances, as in the western and northern States, while in the South that agency which is recognized there has not been in operation here. In this State, no currents of water have ever swept over the face of the earth, so as to remove the soil to a great distance from the rocks from which it was derived. In the course of time, that which belongs strictly to the present period, however, a partial removal to distant quarters has taken place. This removal was effected mostly by rivers acting locally upon banks of soil, which by little and little were transported to the Atlantic coast, or to inland bays, like the Albemarle and Palmico of our coast.

Now, the soils during the act of removal, were subjected to the

assorting power of water, whereby the coarser parts were separated from the finer and distributed according to the comparative gravity; the finer particles being transported farther than the coarse, and probably in different directions, both laterally and more widely.

The present operations of water illustrate in part the nature of those by which removals formerly took place. We cannot but notice the turbid conditions of the Roanoke, the Neuse and the Cape Fear, during a freshet. It is due to the soil which has been lost from their banks, and which is being transported seawards, but which must subside in part, before the waters reach their destination. In freshets, the low grounds are inundated with this muddy water, and it frequently happens that an inch or more of fine soil is deposited at certain places which are favorably situated, or in places where the waters are unagited by the rapid currents. What is usually seen, however, is along the immediate banks of the rivers, and it is not unfrequently the case, that all the old vegetation, however rank, is buried, or concealed beneath the sediment. But in addition to this heavy deposit, there is still a finer one which is carried by the water into lateral marshes, and this water, though robbed of a part of its burthen, still retains the finest, which slowly settles among the moss, reeds, grasses, &c., which belong to this peculiar formation. These waters are slowly drawn off, and perhaps even remain for weeks, and are only disposed of by mid-summer, by evaporation, and during the time vegetation is active while it is receiving the fine sediments of the overflowing rivers. In conditions like the foregoing we probably find the best swamp soils formed, inasmuch as there is added to to the growing mosses fine sediments which become the basis of the best of soils, and which are intimately intermingled with an abundance of fertilizing matter in the condition of peat.

Such is the process by which the best swamp lands are made, while the poorer being situated where only the white assorted sand has access. When the sand and vegetation has reached a certain hight, or has attained the level of ordinary freshets, vegetation still goes on, and moss, grass, and certain herbaceous plants and trees, still grow, until the surface upon which they stand is higher than the margins. The whole mass of vegetation which grew in former years is like a sponge, and it is at all times nearly

aturated with water. In this condition it receives no further addition of soil; it is a mere growth of water living vegetables which maintain their place by their constitutional adaptations. This vegetation is divisible into two parts, the dead and living; the former beneath, the latter above. This *status quo* is maintained solely by the low temperature of the swamp. All the vegetation below is as it were, water logged, and in process of time it simply blackens, as it is a water charring; and when it has become peat it undergoes no farther change. This is the exact condition of many swamps; above they consist of a mass of vegetation of the poorest plants, the mosses and coarse grasses; and for trees, some pines of a small size, and many bays or magnolias. Let such a swamp be drained and it subsides from a one to two feet; a change which is confined to the upper part. In early days, or when first forming, sand was received from a distance, or it may have been laid down upon an old sandy sea bottom. But it has generally happened that the lower parts of the vegetable mass is mixed with sand, showing that though the swamp was based upon a sea bottom; yet, being basin shaped, it continued for a time to receive materials from a distance. The age of these deposits is no doubt recent. They repose upon the eolian sands, and generally, so far as their bottoms have been exposed for examination, they belong to most recent coast deposits, and yet, it is probably true, that they extend far back beyond the settlement of the coast. Still, they are properly modern formations, and are entirely connected with the present state and arrangements of the present line of coasts, and the river systems coming in from the interior.

It is probably true, that as to agricultural value, it will prove that those which are the highest or have become higher than tide water by growth of vegetation, they are of less value while those which are so situated that they receive the overflowings of rivers until a late period, and hence are last formed, are the most valuable. Hyde county, for example, is only about 4 or 5 feet above storm tides. The Dover swamp in Craven county, we believe, is nearly 60 feet; the first is excellent land, and the latter worthless,—or comparatively so. In the same field, however, with these poor swamps we may often find fertile islands capable of bearing heavy crops of corn. The means by which such islands may be recognised will be stated farther on.

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## CHAPTER IV.

Geographical position of the swamp lands, and their extent in North-Carolina. Defective information in the public archives of the State. The Savannah lands, etc.

§ 10. The lands under consideration are confined to the eastern counties. They scarcely touch the long, narrow sounds which skirt the Atlantic. Large bodies extend from fifty to one hundred miles from the ocean, and occupy wide belts, not far from, and parallel with, the principal rivers. Their shape is, however, irregular, and it will be seen by the inspection of any correct map, that they must occupy ground considerably higher than the beds of the river which they skirt. They are reservoirs of water, and numerous streams issue from them on all sides which find their way to the river channels by exceedingly crooked routes or courses.

§ 11. The most northern swamp is a continuation of the great Dismal, lying partly in Virginia and partly in North-Carolina, and which occupies large tracts in Currituck and Pasquotank counties. Pasquotank river rises in this swamp, its head being really in Lake Drummond, in Virginia. Towns and numerous hamlets, however, are planted in the great Dismal Swamp. It is traversed by roads, and few in passing through this section of country would suspect they were in this swamp, famous the world over for its ominous name.

The largest territory of swamp lies in Washington, Tyrrell, Beaufort and Hyde counties. Its whole length is rather more than seventy-five miles from east to west, and at least forty-five in the widest part from north to south. It lies between Albemarle Sound, the lower Roanoke River, and Pamlico Sound, Pamlico and Tar Rivers. The most eastern parts of this great tract, however, should be regarded as *marsh land*, and subject to overflow during storm tides. Like all swamp lands, the middle is higher by a few feet than the margins. It terminates westward, near Washington, Beaufort county. This great body differs from other swamps by a more uniform continuity, and a more perfect level, and with fewer knowles, called *islands*. Hyde county, for example, is level as a house floor, and as even as a well constructed garden. It is but a

few feet above tide; too few to give depth for wells, and hence, water for cooking is supplied mainly from cisterns resting upon the ground. This swamp has four shallow lakes of considerable size. The largest is Matamuskeet, which is twenty miles long. Lying a few feet lower than the swamp are tracts of stiff clay soil, probably as good for wheat as any in the State, but these diverse kinds are never intermingled; the clay is a kind of outlier or border. The lands of this great swamp have become famous for the large crops of corn they produce. They are called the Hyde county or Matamuskeet lands.

Again, included between the forks of Pamlico and Neuse Rivers is another swamp thirty miles long, but in area, it is less than an eighth of the Matamuskeet Swamp and Pungo Swamp.

South of the Neuse, and lying in Carteret and Jones counties, there is another immense tract of swamp land, 80,000 acres of which is known as the open prairie of Carteret. In nearly a continued belt this swamp is 75 miles long from east to west, but its width is less than the Matamuskeet swamp. It is not by any means perfectly continuous. It admits the passage of roads, but it lies nearly upon one plane, and the slight inequalities scarcely serve to divide it into separate sections.

Dover swamp is an isolated tract some fifteen miles in length, and is crossed by the Atlantic Railroad.

Onslow and Jones counties contain a part of the great Carteret tract. This tract, at its western extremity, gives origin to the White Oak creek.

Holly Shelter swamp lies parallel with east Cape Fear river. It begins in Onslow county, but the greatest part lies in New Hanover county, east of the Wilmington and Weldon Railroad.

In Brunswick county lies the Green swamp. It is rather lower than those we have mentioned, but it is peculiar in having numerous islands; that is, rounded hillocks, but slightly elevated above the general surface of the swamp. These are inhabited by squatters, who live by basket-making, and by general plunder of those materials which can be turned into hominy, hoe-cake and a little bacon. On the border of this swamp there has been formed a beautiful lake with clear water, and known as Waccamaw lake, and from which flows the Waccamaw river, a boatable stream, though it is liable to be blocked up by trees and dead timber.

Livingston's creek rises in this swamp, and is boatable from the Cape Fear to the crossing of the Manchester Railroad, and up which the tide flows twelve miles, rising something like two feet at its mouth. Columbus county contains large bodies of swamp land, but not so continuous as the Green swamp of Brunswick.

The whole number of acres of swamp lands in the State is at least two millions, of which the State owns *one million five hundred thousand*. This, however, does not include the marsh lands bordering the sounds. There are also smaller tracts owned by individuals, of considerable value, in all the counties we have named. There is, however, a deficiency of statistics and records of surveys, and although the swamp lands are vastly important, the archives of the State furnish reallv no information of value. Private individuals who are personally interested in large tracts of those lands, have furnished all the reliable information we possess relative to them.

In contrast with the swamp lands, we may briefly notice the Savannah lands. These are beautiful, open and level spaces, covered now with broom grass. We have not been told what they produced in early times. The largest in the State lie on both sides of the Wilmington and Weldon Railroad, in the county of New Hanover, and not far above Wilmington. A traveler passing over the road in the day time, will admire their beautiful surfaces, though they are not covered with brilliant flowers and the more valuable crops of cereals.

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## CHAPTER V.

**Temperature of soils. Distribution and circulation of heat.**

§ 12. Every plant and every crop requires a certain temperature for its perfection; not that it requires exactly such a number of degrees of Fahrenheit, but crops and plants require for perfection a limited range of temperature, and this limited range may be

regarded in the light of a special latitude. The source of heat is the sun. Its rays penetrate or affect the soil in this latitude to the depth of probably 100 feet. At this depth a thermometer would remain stationary the whole year, being changed neither in summer nor winter. The summer's heat will not cause it to rise, nor the winter's cold to fall. In this space, in consequence of the continued action of the sun's rays in spring and summer, heat accumulates, especially in the upper beds of soil, and the roots of plants, and as the fall and winter set in, receive from beneath, the heat which has accumulated. The surface layers become cold as autumn advances, but beneath, the store which has accumulated keeps the roots warm, and probably tempers or mitigates the cold above. But the cold season expends the stock, and when the spring comes round with its showers, its buds and flowers, the sun's heat is found to be penetrating again the depths of soil with the same intensity as in former years. It cannot be affirmed that the season begins with a portion of the old stock of heat remaining, for in that case there would be ultimately a great excess of heat in the soil. Each year's observations give the same average results in the same latitude.

In the spring and summer the accumulation has a certain uniformity of increase and decrease. The increase reaches its maximum by the middle of August, when the heat of the soil diminishes, though sensibly, the temperature of the air remains for a week or two much the same as in the first part of the month. The stock of heat is gradually expended. The winter is undoubtedly milder and softer in consequence, and vegetation is thereby less exposed to injurious extremes of cold, especially their roots, which will be preserved alive in many instances, though the stem may be killed.

Surfaces, however, are affected differently. Water becomes heated much less than the soil, and to a certain extent we are safe in affirming, that its penetration is governed by the dryness of the surface and its color. A wet surface having the character of a sponge, will remain nearly as cold as a water surface. The principle is well understood; for as we have already stated water evaporates at all temperatures, but it cannot evaporate in the total absence of heat, but however cold it may be, the vapor which rises absorbs a certain amount of heat. The heat of a body saturated with water is kept cold by the escaping vapor. Pour ether upon

hand, or any other substance which vaporises rapidly, and a great degree of cold is felt. The hand parts with its heat or as it is technically called, its caloric, and it is precisely so with soil, with a sponge and the swamp lands of the Eastern counties. It is to the coldness of the surface or the vegetable mass caused by evaporation, that it has been preserved, and by which it is kept cool. The swamp lands, however, have a double protection; first, a thick forest, and an under-growth of water shrubs or grasses, and then the mantle of water for a part of the year, or for the whole year, a fountain of water which is sufficient to feed the spongy turf, or mosses of the surface. If water escapes in vapor from the surface, it is instantly supplied with more, just as a sponge is kept wet when its base rests in water and its temperature will not rise until all the water is evaporated. The following experiments establish the foregoing statements:

On the 21st of April, between 9 and 10 A. M., the temperature of the air was 72.

The temperature of a water covered surface 64°.

That of a boggy place in the sun 10 feet distant, 64°.

At another similar place, 62°.

And at a wet grassy surface shaded in part, 62°.

Temperature of the soil imperfectly drained, 68°.

Temperature of a light colored granite soil well drained 70°.

Temperature of a red soil well drained at the surface, 74°.

Its temperature six inches deep, 68°.

Temperature of a black soil at the surface 90°; 3 inches beneath 82°; 6 inches beneath 80°; showing a gradual penetration of heat downwards. In January 22d, the temperature of the air was 41°; temperature of falling rain 45°; temperature of the earth 44° at the depth of 6 inches. The wet surfaces are invariable colder then than the dry; the light are colder than the colored; and the black warmer than either.

The black surfaces were made so, by fine charcoal which was intermingled with a gray granite soil.

The black soils of the swamps when laid dry become sufficiently warm for the perfection of indian corn even when water stands in the furrows a part of the season.

The preservation of the body of vegetable matter forming the swamp lands is due to two causes: 1st, low temperature; 2d, the

exclusion of air containing oxygen, which is the agent which combines with the organic matter and forms with them humic, crenic, apocrenic acids, and which in their turn combine with ammonia, lime, magnesia, and iron, and which are supposed to be the food of plants.

The temperature of the earth from January 22d to April 21st has advanced from 41° to 68°–70°. The color causing an increase according to its depth; and black soil at the depth of 6 inches reaching 80°.

At a later period it is sometimes found to rise to 120° when exposed to the sun when a marsh near by was only 67°.

From the foregoing facts we may readily surmise what is needful to be done to increase the surface as well as bottom heat. The most rude savage, if he had any idea at all respecting indian corn, would never plant it in a wet place; he would select a dry surface. But, having done this, it is not certain that in every case it would be possible to increase the heat of the soil by artificial means. However, as dark soils become warm in proportion to their depth of color, we may, under favorable circumstances, mix black substances with the soil, such as char coal and peat. Wheat grows better on a stiff red soil than a stiff light one. In most cases the color demonstrates that chemical action has progressed farther than in a light colored soil. In the former the iron has become, at least in a part of it, saturated with oxygen. One part may remain in a protoxide; and if there is organic matter in the soil this is certainly the case, as it deoxidizes the peroxide, a change which is supposed to be a very important one in reference to the formation of ammonia in the soil. In connexion with the subject of cold and warm soils, we may state a beautiful compensation with regard to the distribution of heat. The loss of heat by evaporation has been fully stated, but it may not have occured to the common reader that the reverse takes place when this vapor condenses again as it is carried landward, and as the air hovers over the soil with its load of water, every object cooler than itself is moistened with dew, and the heat of this vapor is imparted to the surfaces on which it is deposited. When, however, equalization of temperature between the air and bedewed surfaces has taken place, it is no longer formed. The properties of air, whether as a carrier of moisture and heat, or as a moving body, are eminently adapted to

the wants of vegetation; they are what the farmer wants for his crops; doing that in the simplest and gentlest manner possible to supply the necessities of the infant plant. They are cooled in the hot sunshine by evaporation, and warmed by the dews of the evening, and are thereby saved from the chills which the absence of the sun tend to produce. Water, as most persons on reflection will perceive, is a material proper to our earth as much as oxygen, silex or gold; but heat is in one sense a foreign product, not to call it matter, originating in the operation of forces peculiar to matter. The great source of heat which the outward parts of the earth enjoys is derived from the sun. It is distributed by numerous agencies, but its nature is such that the heat of one year passes to the celestial spaces, and what is enjoyed the next is a new emanation from the sun and from the active agencies of earth. It is not, then, like water, preserved from year to year by a conservative force; but we are indebted for its continuation to the constant action of the sun and the terrestial forces which are appointed to furnish it from their store houses.

These remarks, we are aware, have no connexion with swamp lands that we can perceive, and still they are not to be regarded as entirely useless, especially when taken in connexion with the remarks concerning the conservation of water and its perpetual residence upon the earth's surface and connexion with the atmosphere.

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## CHAPTER VI.

Swamp lands divided into six districts. The Dismal swamp district has not been explored. Diversity of composition of these lands. Elevated in the middle.

§ 13. The swamp lands of North-Carolina may be regarded as forming six districts. The first beginning on the north, is the Dismal swamp, which lies both in Virginia and North-Carolina. The

second is the Albemarle and Pamlico swamp district, lying between the Albemarle and Pamlico sounds. This large tract is of a quadrangular form and occupies large areas in Tyrrell, Hyde, Washington and Beaufort counties, and probably has the largest acreage of any swamp in the State. It is also the type of all the rest, and will by itself represent every variety of this kind of land which is found in either of the others.

The third is Bay river district, lying between Pamlico and Neuse rivers, both of which in their lower reaches, swell out into wide bays.

The fourth is Carteret county district, lying between the Neuse and Bogue and Core sounds. In this lies the great open prairie tract of eighty thousand acres, and which is owned mostly by the State.

The fifth is the Holly Shelter swamp, including Angola bay, lying between New river and the East Cape Fear.

The sixth is Green swamp, lying mostly in Brunswich county.

The Dismal swamp district has not been sufficiently examined to enable us to speak definitely with respect to its agricultural character. It is believed to furnish the characteristics of the other districts. A single analysis of a specimen of its soil in the early part of the survey, and which was procured within a few miles of Elizabeth City, gave results closely resembling those taken from Hyde county.

The examination of the second district has been much more extensive, having procured samples of soils from all sides of this extensive tract. This we have regarded as particularly worthy of attentive examination and illustration, as it furnishes the best types of soil with which the others may be compared. Those of Hyde county are the best known, and when it is found that a soil has a composition similar to those of this county, we are sure that they will be productive.

It is not designed to intimate in the foregoing statement, that this large tract has been crossed, or traversed extensively. It has been examined, however, in Tyrrell county, in Hyde, on both sides of Matamuskeet lake, in Washington and Beaufort counties. We have samples of soil which no doubt represent all the varieties which occur in this great tract. It is proper to observe in this place, that the swamp lands of this State present as much diversity

in composition as those of the middle or western counties. For example, as it regards the quantity of vegetable matter; some are composed almost exclusively of it, while in others, it is reduced to a minimum, and thereby scarcely differ from ordinary soils. We find between these, extremes of every imaginable variety in the quantity of vegetable matter, though to the eye there is a very close resemblance. Besides in the counties above named, there are large tracts which are well adapted to the growth of wheat, being composed of large proportions of clay, with only the ordinary quantity or per centage of organic matter.

There is still another interesting fact which should be noticed here inasmuch as it is applicable to all the large tracts of swamp land; it is, that they are all higher in the middle than upon the borders. This explains the fact why the streams all flow outward. They all originate in a culminating belt, or crown; and it is this interior belt, which gives in analysis the great excess of vegetable, while the outskirts contain a greater porportion of inorganic matter. This statement however, does not always hold good; yet it is so common as to be worthy of notice. Hence too in ditching, it is necessary to keep the cut level or down, so as not to run out in its progress towards the crown of the swamp. We shall also expect from the foregoing to find the vegetable matter increasing, and perhaps to be approaching to that extreme, that it will not be advisable to attempt to bring it into immediate cultivation.

The miner, in his trials for gold, follows if possible the lead to the vien, the great depository of metal; the farmer or planter, will proceed something in the same way, trying at short intervals the mass for the purp se of determining the quantity of earth, or soil which is intermingled with the vegetable matter, inasmuch as cultivation turns, we think, on the quantity which it contains, at least in the present state of our agricultural knowledge.

As many variations exist in composition, so it will be found that there will necessarily occur equivalent variations in value. In order to determine the value of any part of the uncultivated sections they should be compared with lands under cultivation and which have been proved by experiment. Certainly this course must be regarded as the safest, though we believe that it is not difficult to arrive at a safe conclusion provided the proper steps are taken to determine one or two points, the quantity of soil in the

mass, and its condition whether it is fine or coarse, or is made up entirely of marine sand. In this case it certainly is better than an entire absence of mineral matter; yet, if it is to be cultivated other elements must be added.

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## CHAPTER VII.

Composition of swamp lands stated. Hyde county. Natural crop is Indian corn. Number of plants to the acre. Quantity raised.

§ 14. The composition of the swamp lands, which now claims attention, will be as fully stated as seems to be necessary for a full knowledge of their peculiar properties. In doing this it is regarded as expedient to bring together all the analyses which have been made which are trust-worthy. As it regards those which were given in the report for 1856, they will be also restated as they have been re-examined and additional results obtained, which were necessary to make them complete. Hyde is an ancient county. It occupies the eastern part of the 2d district of swamp lands; is elevated only a few feet above the tide storms of the coast. The marsh lands everywhere skirt the best swamp land, but they are never included in those which are under consideration, even such parts of them which are only rarely overflowed by tides. They are too saline for the cereals, or the fine meadow grasses.

It is in this county that the durability of swamp lands has been tested. The records of the courts and reliable tradition show that certain tracts have been under constant cultivation over a century with a yearly crop of grains, principally indian corn, without showing a decrease in the number of bushels per acre or any diminution in the fertility of the soil. It is rather maintained that they improve under cultivation; and this is not surprising, because they are brought to a condition more favorable to vegetation in consequence of the free admission of air and the disappearance of

an upper surface too much charged with vegetable matter. Besides it becomes more compact, and is better able to support the heavy foilage. In a loose soil the roots are unable to sustain the foilage and keep it upright against the force of strong winds which sometimes visit the low counties. The roots are liable to be broken or injured in resisting its force. Though the soil is still to be regarded as light and loose, it is not spongy, and water rises through it as in other soils, though moisture is favored by the presence of a large amount of vegetable matter.

The color is black or dark brown, as already indicated, and the whole mass near the surface looks as if it was composed entirely of vegetable matter. We see no particles of sand or soil in it. On the sides and bottoms of ditches a light gray, or ashy soil is discernable. Indeed, it is regarded as ashes, and is so called, and is supposed to have been formed by the combustion of ancient beds of vegetable matter. The cultivated lands of Hyde are not chaffy, that is when dry, like tinder and liable to take fire from a spark or ignited by a gun wad. There are, it is true, tracts lying in connexion with them of this character, which are quite limited, but their occurrence does not affect this general characteristic.

The following substances with their proportional numbers express the composition of a soil which has been under cultivation three years. The tract is owned by Dr. Long, and is a part of an old plantation which has been under cultivation for more than one hundred years:

| | |
|---|---|
| Organic matter, | 46.10 |
| Silex, | 43.00 |
| Oxide of iron and alumina, | 6.40 |
| Carbonate of lime, | 0.21 |
| Magnesia, | 0.12 |
| Potash, | 0.16 |
| Soda, | 0.18 |
| Chlorine, | trace. |
| Soluble silex, | 0.03 |
| Sulphuric acid, | 0.04 |
| Phosphoric acid, | 0.30 |
| Ammonia, | 0.09 |
| Soluble organic matter, | 2.00 |
| | 98.60 |

The silex of this soil is exceedingly fine and of a drab color. It is too fine to detect with certainty its origin. When it is a grade coarser, it frequently contains particles of mica and felspar, indicating that the parent rock from which it was derived, were the common granites which skirt the low country, and which form a distinct belt, running nearly north-east and south-west. If this earth constituted by itself the main body of soil, it would be too fine, and form a mass too compact to admit the free penetration and circulation of air. In this respect it resembles the fine grained soils of some of the western States, and which are easily moved and blown into clouds by strong winds. The intermixture of vegetable matter makes it sufficiently porous, and by its agency preserves that open state so needful for the promotion of chemical changes, the development of carbonic acid, the deoxidation of the peroxide of iron and the absorption of ammonia. The lime does not probably exist in the condition of a carbonate; it is the state in which it is obtained; but probably as it exists in the soil it is in combination with an organic acid, which during the combustion is converted into a carbonate.

The alkalies are less in quantity than we should naturally expect from soils so productive.

But what at first appears remarkable, is the small quantity of chlorine and sulphuric acid. Both seem to be nearly absent; it is rarely that we attempt to weigh them. Whether their absence is due to the original wet state of the soil, we are unable to form an opinion. We should expect to find chlorine in a soil so near the ocean that during storms it must be taken up and carried inland, and from this cause it would be expected that it would at least appear in a per centage as large as in soils a hundred miles from the ocean.

The composition of the subsoil it will be seen differs from the former, taking a quantity two and a half feet from the top from the side of a ditch free from growing vegetables we found it had the following composition:

| | |
|---|---|
| Water, | 7.50 |
| Insoluble organic matter, | 16.30 |
| Hunic acid or soluble organic matter, | 3.70 |
| Silex, | 59.88 |

| | |
|---|---|
| Alumina, | 7.90 |
| Peroxide of iron, | 2.10 |
| Carbonate lime, | 50 |
| Magnesia, | 32 |
| Phosphate of lime, | 50 |
| Potash, | 15 |
| Soda, | 12 |
| Silicic acid, | 14 |
| Ammonia, | 09 |
| | 99.10 |

The color of the subsoil after drying is brown and particles of fine sand are distinguishable. It often shows light or gray patches which are regarded as ashes derived from ancient combustions. It is due to the inorganic matter which gives a lighter color to the mass. The soluble organic matter is large in this instance. The quantity of ammonia is smaller at this depth than at the surface.

The constitution of this part of the soil is excellent, possessing all the elements which are necessary for the growth of crops. The specimen for analysis was taken about midway between the top and bottom of the mass of soil; below, it preserved the same composition apparently or so far as mechanical exploration could furnish information, though it is probably more highly charged with soil as it seems to increase with depth. But taking the whole mass of soil which is about six feet deep at this part of the plantation and not less elsewhere, there is in sight a large store house of matter to sustain the crops, or any future vegetable growth.

§ 15. This plantation, which has been under actual cultivation for a period sufficiently long to test most thoroughly the capacity of the Hyde county soils for endurance, is at present the property of Dr. Long of Lake landing. Its ownership can be traced back for six generations, and the crops which have been removed have necessarily been confined to the cereals and probably Indian corn, with an occasional crop of wheat, which is cultivated for the purpose of occupying the land with something more profitable than a heavy growth of weeds. It is necessary they should be excluded by occupation.

The composition of a sample of this soil, which has been so long under the plow, has been determined with the following results:

| | |
|---|---|
| Water, | 8.90 |
| Silex, | 59.00 |
| Insoluble organic matter, | 18.80 |
| Humic acid or soluble organic matter, | 3.40 |
| Peroxide of iron and alumina, | 8.00 |
| Carbonate of lime, | 0.10 |
| Magnesia, | 0.09 |
| Potash, | 0.04 |
| Soda, | 0.08 |
| Silicic acid, | 0.20 |
| Phosphate of lime, | 0.62 |
| Sulphuric acid, | trace. |
| Chlorine, | trace. |
| Ammonia, | 0.25 |
| | 98.96 |

This soil is shown to contain less organic matter than the first, and a larger proportion of silica. The first element must necessarily diminish under cultivation more rapidly than can be accounted for by removal in the crop. It is consumed by exposure to the elements, undergoing a change analogous to combustion, and which Liebig has termed *eremacausis.*

The quantity of corn which is cultivated per acre, is reckoned by the number of plants allowed to stand. The common rule in Hyde county, we believe is to cultivate fourteen thousand per acre; and it is common to allow two or three plants to grow in a hill. A crop made up or consisting of such a number of plants per acre will give a stranger a correct knowledge of the capabilities of the soil. But it should be observed that the immense growth of foilage with stalks is somewhat out of portion to the grain, and it appears, that maize, growing in a very rich soil, runs somewhat to foilage, though not to the excess which is observed in oats, wheat and other cereals. The hight of the corn, upon an average, is 12 feet high. The grain is rather lighter also than northern or western corn, and the ears, taken as a whole, appear rather less than when grown upon soil with less vegetable matter.

The usual crop is between 10 and 12 barrels of 5 bushels, to the acre. If heavy winds in the early part of the season, or other agents act unfavorably, it will be diminished to 9 or 10 barrels per acre, while in favorable seasons it reaches twelve barrels.

The result may not strike a person as remarkable; but it should be considered that no manure is called for, and the simplest and cheapest mode of cultivation is all that is required to make a crop of this standard, and this is the common result, without an expenditure in money and labor for manure. Therefore, there is a larger profit, though it is not uncommon to obtain a larger yield, but it is done at a heavy expence in fertilizers and labor.

§ 16. The soils analyzed as stated in the foregoing paragraphs, were taken from the south side of Matamuskeet lake. The north side is usually regarded as better land. It is not, however, fully established that this opinion is well founded. The differences are slight, if any. The composition of the soil of the north side is certainly much the same, as we believe. The following is a statement of the composition of a portion of soil from the plantation of Mr. Burrows, taken at a depth of eight inches. It had been under culture for three years:

| | |
|---|---|
| Water, | 12.30 |
| Insoluble organic matter, | 38.80 |
| Humic acid, or soluble organic matter, | 3.20 |
| Peroxide of iron, | 3.70 |
| Alumina, | 5.10 |
| Silicic acid, | 0.40 |
| Carbonate of lime, | 0.48 |
| Magnesia, | 0.27 |
| Potash, | 0.18 |
| Soda, | 0.10 |
| Phosphoric acid, | 0.12 |
| Chlorine, | trace. |
| Sulphuric acid, | trace. |
| Ammonia, | .20 |
| Silex, | 34.60 |
| | 99.05 |

The lands of Hyde follow the same rule respecting the presence of chlorine and sulphuric acid, as all the swamp lands of the eastern and southern counties. Their absence is not satisfactorily accounted for, unless it is due to excessive moisture, or to their removal by constant contact with water. The timber of the soils of the Matamuskeet country are black gum and cypress, both of a

large size. Large pines and poplars are not uncommon, and all are regarded as indicative of a rich soil. This opinion is undoubtedly true, and may be relied upon. It is, in fact, perfectly compatible with all the arrangements and conditions required. While the timber of the poor tracts bear trees of a small size, of a different kind, appear dwarfed or starved, for want of nutriment. The poor soils also bear upon their surfaces indications equally compatible with the conditions in which they are connected, but in the latter it is perhaps a condition which may be greatly improved.

§ 17. It will be useful in passing, to compare the swamp lands with the prairies of Illinois, or any other tract of the great west, whose characteristics have drawn westward so many emigrants from New England, New York and the old world.

The soils of the prairies have a great natural fertility, and which it is supposed by many are so excessive that they will bear cultivation for thousands of years, though not without the aid of fertilizers. Large tracts in Europe, Lombardy, for example, have yielded crops for two thousand years. But Lombardy yields her crops, and has done so from time immemorial, by the aid of fertilizers, and which are husbanded in a manner and with a care, which is unknown out of that country. Calculations are made to a penny, what a pound of any given fertilizer is worth. It is a money article. The long period during which Lombardy and England have been cultivated, and are still productive, proves the value of the basis of the soils upon which agriculture has rested.

§ 18. A prairie soil of Illinois is usually black, or brownish black and friable, from an intermixture of earthy or sandy matter. It has a basis or subsoil of a stiff yellowish clay, and such is the nature of this soil, that it has borne a succession of crops of maize for thirty years, and even more, without manure. These lands are better adapted to maize than wheat, and partly so for the same reasons that this crop succeeds better in all the swamp lands than wheat. Besides, the open prairies are swept in the winter by strong chilling winds, which injure wheat by rooting it up. Such influences must bear annually upon lands thus exposed. The crops of corn are larger than in Hyde county, but whether they sell for as much money, is quite doubtful. A prairie crop often reaches a hundred bushels per acre. The farmers of Hyde seem

to be contented with 60 bushels per acre, and at the same time we see no reason why they too might not increase it to 100 bushels. The composition of the prairie lands furnish some differences, but there is so much uniformity that they appear to form only one class.

§ 19. An example or two showing the composition of the best of the class will suffice for a comparison with the Hyde county corn lands. Thus, the best kind consists of:

| | |
|---|---|
| Organic matter and water in combination, | 9.05 |
| Alumina, | 3.38 |
| Oxides of iron, | 4.30 |
| Lime, | .54 |
| Magnesia, | .35 |
| Potash, | .19 |
| Soda, | .08 |
| Phosphoric acid, | .10 |
| Sulphuric acid, | .08 |
| Carbonic acid and traces of chlorine, | .09 |
| | 100.00 |
| Ammonia, | 41 |
| Containing nitrogen, | 34 Prof. Voelcker. |

§ 20. Prof. Voelcker remarks* that the soil is not rich in phosphoric acid, but still, there is an ample store to meet all the requirements of the plants usually cultivated upon the farm. The great and important distinction in the composition of the prairie soil and swamp lands, is the great excess of vegetable matter in the latter. The prairie soil possesses no advantages in point of composition with respect to the expensive elements, *phosphoric acid*, *potash*, *soda*, *lime*, *etc.* The prairie lands must necessarily require fertilizers at an early day, while the magazine of food in the swamp lands will require centuries before it can be consumed, even under constant cultivation.

Another variety of prairie soil analyzed by Prof. Voelcker is regarded as less fertile than the preceeding. It is composed of:

---

* Prairie farming in America, by James C. Caird, M. P.

| | |
|---|---|
| Organic matter and water of combination, | 5.76 |
| Alumina, | 1.57 |
| Oxide of iron, | 2.57 |
| Lime, | 35 |
| Magnesia, | 40 |
| Potash, | 33 |
| Soda, | trace. |
| Phosphoric acid, | 05 |
| Sulphuric acid, | 05 |
| Carbonic acid, and traces of chlorine and loss, | 53 |
| | 100.00 |
| Ammonia, | 0.31 |
| Containing Nitrogen, | 0.26 |

The proportion of nitrogen, says Prof. Voelcker, is less as might be expected from the smaller quantity of organic matter. However, two tenths per cent. is regarded as a large proportion though when expressed in fractional numbers it appears insignificant, yet when it is known that the weight of soil, ten inches deep upon an acre amounts to a thousand tons in round numbers, the quantity of nitrogen in an acre of soil existing in this proportion will be about two tons. A crop of wheat of 36 bushels to the acre with its straw, contains fifty two pounds of nitrogen, and a crop of Swedish turnips only about thirty-six pounds.

In this connection it will be instructive to many to see the composition of a rich wheat soil of Scotland analyzed by Prof. Anderson. It is from Mid Lothian and consists of:

| | |
|---|---|
| Organic matter and water, | 10.19 |
| Alumina, | 6.93 |
| Oxides of iron, | 5.17 |
| Lime, | 1.22 |
| Magnesia, | 1.08 |
| Potash, | 0.35 |
| Soda, | 0.43 |
| Phosphoric acid, | 0.43 |
| Sulphuric acid, | 0.04 |
| Silica, | 71.55 |
| Water, | 2.58 |
| Carbonate acid and loss, | 0.03 |
| | 100.00 |
| Nitrogen, | 22 |

§ 21. Several analyses of swamp soils have been made, which, at the time, were regarded as owned by the State, but subsequently we were informed were taken from the lower part of the valley of the Mississippi. They were furnished by the Hon. B. F. Moore of this place. It is impossible to find marks by which No. 1 may be distinguished from a Hyde county soil. They were numbered up to seven. No. 1 is black and fine, showing that the vegetable matter has passed into the condition of well formed peat. It gave, on analysis:

| | No. 1. | No. 3. |
|---|---|---|
| Water, | 14.50 | 2.50 |
| Organic matter, | 51.79 | 6.00 |
| Alumina and oxiron, | 3.63 | 3.50 |
| Silex, | 28.20 | 87.50 |
| Lime, | 1.00 | 0.20 |
| Magnesia, | .50 | .10 |
| Potash, | .07 | undetermined. |
| | 99.69 | 99.80 |

No. 3 corresponds to some of our best gall berry lands, which are low and wet; it has a drab color, and a fine silicious base, and is a tolerable good soil.

Another which is still more sandy, and less coherent, resembles our gall berry soils and must rank with poor soils. It consists of:

| | No. 6. |
|---|---|
| Water, | 2.00 |
| Organic matter, | 2.00 |
| Silex, | 90.00 |
| Oxide of iron and alumina, | 4.00 |
| Lime, | 8.40 |
| Magnesia, | 0.06 |
| Potash and soda, | undetermined. |
| | 98.46 |

The organic matter of No. 6 is reduced to the minimum quantity of excessively sandy soils.

These analyses from a distant part of our country are introduced for the purpose of noticing a fact which is not uncommon in soils

of this class. It is the occurrence of poor patches in the midst of No. 1, which is a rich and productive soil. But these spots of barrenness bear the plant until it is a foot high, when it turns yellow and dies. This kind of material is loose and chaffy; it contains 65 per cent. of vegetable matter, but it is loose and rather coarse, and probably furnishes one reason why vegetation dries up so early. It is not deficient in inorganic matter, but growth requires a body of soil which has firmness, but it is possible that these barren places contain the astringent salts of iron and alumina. There are several places in North-Carolina where the vegetable matter contains an acid salt of iron, which destroys corn or any other vegetable productions when it is placed in contact with them.

§ 22. A practical method for obtaining a sufficient knowledge of the swamp soils to enable the owner or purchaser to form an opinion of their value, and which may be performed by any person possessed of patience and care, is by adopting a mechanical process. Take about a pound of soil, with or without weighing, and with water in a clean dish or saucer, and then with the fingers rub the mass fine; allow it to settle, pour off the black liquid and the matter which floats in it. This consists of vegetable matter separated from the mineral. The operation is to be repeated as long as the water is discolored, being careful not to pour off or waste the soil. After several washings the fine sandy particles begin to appear in all the best soils. If, however, the soil is poor, white coarsish sand will appear in place of the gray fine material, which characterises the Hyde county soils, or those which are similiar to them. The operation is by no means difficult, but requires care to save the soil when it is fine; indeed, one-third of it will probably be lost in the most careful performance of the process, but enough soil will be obtained to show its character even though the operation is hastily performed.

Two results, obtained mechanically, will be given in this plan. The first is Dr. Long's soil, which had been under cultivation over a century, and the second a soil from the north-side of the lake.

Thus 100 grains, on being carefully washed by the foregoing method, gave :

| | | |
|---|---|---|
| Very fine soil, | 41.0 | |
| Fine sand or soil, | 18.0 | grs. |
| Vegetable matter, | 22.00 | |
| | 81.00 | |

The result shows that more than one-half is very fine, the remainder less so. The soil, under the microscope, showed scales of mica and grains of felspar, which indicate a derivation from granitic rocks. On being heated to redness the whole becomes a drab color.

The soil from the plantation of Mr. Burrows, on the north side of the lake, treated in the same way, gave:

| | | |
|---|---|---|
| Very fine soil, | 28.40 | |
| Fine, | 16.20 | grs. |
| Vegetable matter, | 47.90 | |
| | 86.30 | |

The color was a light gray, and on being heated to redness was only slightly redened. There again the loss was about one-half, as when the vegetable matter is consumed, it leaves 44.30 per cent. of a compound which is mostly silica, which, as in the former specimen, is extremely fine.

§ 23. In order to show the difference between a rich soil and one which is comparatively poor, we shall place one of the latter in this connexion. It is from the Carteret county lands or the open prairie. Thus, on mechanically separating the inorganic matter, we found:

| | |
|---|---|
| The coarse part amounted to, | 27.00 grs. |
| The fine " " " | 7.58 |
| Organic matter, | 44.22 |

The fine and valuable part bears a small proportion to the coarse which can scarcely be relied upon for furnishing nutriment. However this may be, it is useful in assisting to give solidity to the mass of vegetable matters.

We propose to introduce, in this connexion, the remarks of Messrs. D. Simmons & Brother, of Hyde county, accompanying

two analyses of soils by Prof. N. B. Webster, of Portsmouth, Va. They were marked A and B. The first consists, according to Prof. Webster, of:

| | |
|---|---|
| Moisture, when air dried, | 14.00 |
| Vegetable matter, | 58.00 |
| Silex, very fine, | 14.00 |
| Alumina, | .06 |
| Oxide of iron, | .03 |
| Lime, | .01 |
| Potash and soda, | .01 |
| Loss, | .03 |
| | 86.04 |

We have copied the analyses from the North-Carolina Farmer, and probably there is some mistake in figures, though the apparent error may lie in mistaking the quantity used in analysis.

The composition of sample B is stated as follows:

| | |
|---|---|
| Moisture, when air dried, | 13.00 |
| Carbonaceous matter, | 68.00 |
| Silex, | 14.00 |
| Alumina, | 0.06 |
| Oxide of iron, | .03 |
| Lime, | .01 |
| Loss, | 4.00 |
| | 100.00 |

The information derived from Messrs. Simmons, distinguished for their successful farming and large crops, is as follows: The sample A was taken from an 80 acre field, lying on the north shore of the lake, and running back half a mile. This land had been in cultivation about 20 years, and produces now, in a fair crop year, 10 to 12 barrels of corn per acre. The sample B was taken from a 640 acre tract, lying back of the 80 acre field. It has been in cultivation five years, and produces, in a fair crop year, from 10 to 12 barrels of corn per acre. These lands lie between Matamuskeet and Aligator lakes, four miles distant from Alligator river. Alligator lake is said to be 10 miles wide and 15 long, and from 3 to 5 feet deep. It lies nearly in the centre of the county. It is sur-

rounded by a ridge from 4 to 6 feet above the sheet of water. The back lands are drained into Alligator river on the north, and into Palmico sound on the south. The cultivated lands on the north side of Matamuskeet lake run back about two miles, and are very uniform in quality. The north side is the best and deepest soil. Indeed, it may be said the county is a garden spot. It has a population of 5,000 to 6,000, and ships from 500 to 600 thousand bushels of corn, and some 50 thousand bushels of wheat per annum, to which may be added large quantities of peas, potatoes, &c."

§ 24. RECAPITULATION *respecting the Hyde county soils.* Their peculiarity consists, 1st, in the extreme fineness of the soil proper, or the inorganic matter. This is of a drab color, and shows by itself a good composition; that is, it proves that it does not consist of a pure marine sand, but that it contains all the common inorganic elements, iron, silica, alumina, lime, magnesia, etc. Those which consist of marine sand alone, and which express by themselves barreness, have an inorganic matter which is white, and any person of ordinary capacity will recognise this element, which, though necessary, is not sufficient by itself to supply the wants of vegetation; it is simply defective in other important matters. Acids, however, acting upon even the white sand, dissolve a fractional part, showing the probable existence of a small quantity of felspar intermixed; and hence, even, in the case of the presence of a white sand, a few crops may be grown.

The great amount of organic matter is a common characteristic; and its presence serves only to distinguish this class, the swamp soils from the upland soils.

Hyde county soils show a greater capacity for endurance than the prairie soils of Illinois; notwithstanding the annual crop of maize is somewhat less per acre. But on the score of location we are unable to see that the Illinois soils have a preference. As it regards health, Hyde county is no more subject to chills and fever than the country of the Prairies. It is a remarkable fact that persons live and labor in swamps with impunity, or freedom from disease. A large amount of vegetable matter, when exposed to the sun, usually generates miasmata, but the common mode pursued for cultivation of the soils of Hyde county will not expose a greater surface, or a greater amount of vegetable matter than is exposed in the breaking up of prairie grounds; and those grounds

when first exposed, or for several years disengage miasmata and generate in the exposed inhabitants chills and fevers. Precautions in both sections of country, no doubt, will enable persons and families to counteract their injurious influences, in part at least, and thereby escape the attacks of fever.

The origin of the soils of Hyde county may be traced to granitic rocks, either granite or gneiss, whose composition is precisely similar. Finely abraded materials being transported from the interior by rivers which frequently overflowed their banks, and distributed thereby the fine soil over low grounds, upon which plants of various kinds were growing. In certain poor tracts, however, coarse sand was admitted and distributed more rapidly, but still over a surface supporting coarse grasses and mosses. As all of the eastern counties were at one time submerged tracts, and received deposits of sand while beneath the Atlantic, it has no doubt often happened that these marine sands have been subsequently disturbed and the sand redistributed by rivers.

§ 25. The position of the great swampy tract to which Hyde county belongs is between the lower reaches of the Roanoke and Palmico sound, a position which shows very satisfactorily what must have taken place in early times when the land was a few feet lower than it is now. We may regard all the tracts which possess a gray or drab colored soil as having received it from the interior, while the clear white sands, which often appear under the microscope as ground crystals, are probably derived from marine beds which have been assorted or sifted by the action of waves. It is by no means an uncommon circumstance that river currents, with their burthens of comminuted rock and tides bearing forward sand meet and commingle their contents, and some varieties of soil are actually composed of the fine and coarse as if they had been mixed in the way we have indicated.

§ 26. The principal fact we have to bear in mind is that soil mixed with vegetable matter is absolutely necessary for the growth of plants. The black peat, if destitute of soil, will not sustain a crop, it necessarily perishes, and the time during which plants or crops of the cereals can grow and perfect seeds or fruit depends directly upon the amount of soil the peat contains combining the necessary elements in due proportions.

## CHAPTER VIII.

Position of Plymouth. Quality of soils indicated by the growth of timber. Cost of drainage. Composition of four specimens of soil from the south side of Albemarle sound. Mechanical separation of elements, etc.

§ 27. PLYMOUTH is a place of some note upon one of the south divisions of the Roanoke, and above its entrance into Albemarle sound some ten miles. It is upon the north side of the great swamp, to which the Hyde county lands, which have been under consideration, belong.

In its vicinity are lands which are owned by gentlemen of Raleigh, and who are now making inroads upon the desert swamp in the way of drains and ditches, aided by the axe and grubbing hoe. Their lands, which are not far from Plymouth, are in an easterly direction, and appear, so far as externals are concerned, closely related to those of Hyde county; but as we have already stated, the swamp lands of North-Carolina are as variable in composition as the uplands; and hence, the necessity of an analysis of some kind to prove or determine their characteristics. It is indeed, highly probable that there is more danger of misjudging of their qualities by simple inspection, than of the uplands; for the vegetable matter masks their essential characteristics, or those characteristics by which their ability to bear crops depend. It is true, that timber in kind and quality, furnishes a clue upon which to found a judgment; and following this guide, it is very probable that good judges would make a wise choice of lands; for it is so fitting that certain trees of a large and portly size should grow upon a fat land, and dwarfish ones, with stinted limbs and mossy trunks, should belong to a lean soil, in which there is a great scarcity of the money elements, that it seems to be be an axiom in the vegetable economy. It is as much established in the vegetable kingdom as in the animal, that fatness and size is due to full feeding, while leanness is due to a lack of nutriment, provided the organs of assimilation are in a healthy state. We look upon the specimens from the north of the Albemarle and Pamlico swamp as representative of that side, as they were taken from a tract of seven or eight thousand acres. However this may be, it is necessary to keep before us the characteristics of those lands which we know to

be good, and which have been amply tested. We ought, however, to bear in mind that tests by actual crops may be sufficient to satisfy practical men, but the results of these very tests harmonize perfectly with well known principles. To the minds of those imbued with principles, the results are precisely what they would have predicted, they would say *a priori*, what the results should be. State the facts truly with respect to the soil, and they would predict results. We have then, two sources of imformation for our guide, *principles* and *tests by experiment*. Principles have certain advantages over tests, as they determine for us before hand, or prior to the application of labor and the payment of money; and hence, may be resorted to when tests by experiments are not convenient and require more time than can be devoted to the matter.

§ 28. The first work which is necessary to subdue a swamp and bring it under cultivation is to draw off the water by drains, and then to kill the trees by *girdling*. The timber when girdled is allowed to stand until dead.

We have been unable to ascertain the expense of subduing swamp lands by draining and clearing. In this State it is generally undertaken by the owners of hands. The highest price we have heard being paid is 16 cents per cubic yard for cutting deep and wide ditches. This is more than the work will cost usually; especially when it is undertaken by the owner, with good hands. The task for a smart negro is to cut 400 cubic feet per day, and one who is industrious finishes it in season to save at least one full day of the week. In draining systematically, lots are laid out in squares of ten acres each; ultimately the water finds its way to the drains and leaves the surface sufficiently dry for cultivation. It is not expected that the surface will be dried the first season, and no profits are obtained the first two years. Corn, however, grows upon the ditches and upon the area drained soon after the mass has settled even among the dead trees after the underbrush is removed. In consequence of the heavy expense attending the subjugation of a swamp, it is necessary that the person who embarks in it, should possess capital, for it is not simply the first cost which is to to be met, but the expenditure has to remain unproductive for two or three years. There is the cost of supporting the hands employed for the time, the interest of the money, and perhaps the outlay for the land, all

of which, either requires cash, or good credit based upon a cash reputation.

The timber immediately shows the effect of drainage and girdling, but it is not intended to apply the axe generally to the large trees. The roots of the gum speedily decay. The tree is spongy and almost like cork; and hence, rots earlier than the cypress. As a general rule, the work of clearing is not so formidable an undertaking as it appears it would be on the first inspection of the towering cypresses, the woods are soft and unlike the oaks, maples, birches, beeches, etc., of a northern forest. We believe that the cost of clearing these lands is less than those of the North, or the well wooded uplands of the South, but we have only insufficient data to form a correct opinion. The difficulty is, very few persons keep a book of expenses for work of the kind, and besides, we believe that as clearing really extends over a period of many years, it is impossible to estimate it. Nature is left to perform as much of it as possible.

§ 29. The section from which the soils were taken, the composition of which we propose now to give, is situated upon the branches of Kendricks creek. This short creek rises in the dismal and falls into the south-side of Albemarle sound. The section is regarded as a part of the Hyde county tract, and to be continuous therewith. We shall give the composition of only four specimens, as they seem to represent the condition and character of this part of the swamp. The first is a brown or grayish brown color and would be pronounced, on inspection, a fertile soil. On drying it concretes into small lumps, which, however, are easily crushed. It shows no sand or soil proper, the vegetable matter being in a sufficient quantity to mask or conceal it, but being rubbed between the fingers, or taken between the teeth, its grittiness is at once perceived. The latter method of trying the swamp soil is a very good one, as if present it will be detected and something relating to its fineness or coarseness revealed. This is numbered 4, and on analysis it gave:

| | |
|---|---|
| Water, | 24.000 |
| Silex, | 48.000 |
| Organic matter, | 18.000 |
| Peroxide of iron and alumina, | 8.900 |
| Lime, | .220 |

| | |
|---|---|
| Magnesia, | .100 |
| Potash, | .177 |
| Soda, | .060 |
| Chlorine, | .090 |
| Sulphuric acid, | trace. |
| | 99.447. |

The silex and inorganic matter is of an ash color, and it is proper to observe in this connexion that the iron is in the condition of a protoxide, being white when precipitated, and resembles alumina unless it is oxidised by nitric acid. It differs from many soils in the color of the oxide, as in some cases it has the pertoxide color and then it is greenish. The organic matter in these cases of uncultivated and recently exposed soil has deoxidised it to its lowest state of oxidation, and this fact illustrates very condusively the influence of inorganic matter in soils. When they have become dry and exposed to the atmospheric agents a part of the iron becomes oxidised, but being always present in a mass of vegetable matter it is again deoxidised under favorable conditions. A succession of changes of this kind take place which as water is decomposed hydrogen is set free, and may, when liberated, combine with nitrogen and form ammonia.

This variety of soil is rather upon the rim of the swamp, but it occupies an exceeding large space. The analysis was made upon the specimen which had not been dried in the open air, and shows the amount of water which it naturally holds. But this large per centage of water, it will be perceived, diminishes the ratio of the other important elements ; and hence the true value of this variety of soil is not expressed in its most favorable light.

The examination of this area of soil suggests its adaptation to cotton. We have seen cotton growing luxuriantly and well supplied with bolls on a similar soil in Carteret county. In the constitution of cotton we can see no objection to a complete success on this soil.

About one-fourth of a mile from the outer rim we find the mass to be richer in vegetable matter or to increase in quantity towards its interior. The specimen is black, fine grained material, but contains unchanged stems of vegetables, or those but slightly blackened. It is a true peat, in most respects to the eye. We took of this

sample numbered 2, two hundred grains and found it composed of:

| | | PERCENTAGE. |
|---|---|---|
| Water, | 100.000 | 50.000 |
| Silex, | 39.000 | 19.500 |
| Organic matter, | 54.100 | 29.050 |
| Alumina, | 4.52 | 2.26 |
| Peroxide of iron, | 1.09 | .54 |
| Lime, | .781 | .391 |
| Magnesia, | .160 | .040 |
| Potash, | .177 | .088 |
| Soda, | .088 | .044 |
| Chlorine, | .090 | .045 |
| Sulphuric acid, | trace. | trace. |
| | 199.335 | 99.978 |

The texure of this specimen is looser than the foregoing. In drying, it concretes and forms rounded lumps which is a favorable indication of its condition, for one composed entirely of vegetable matter dries differently.

The great excess of water in this variety bears unfavorably upon its composition provided it is not left out of the acconnt, but it is plain when drainage shall have had its full effect upon it, the ratio of all the important elements will be greatly increased. Taken all in all, this soil is rich in productive elements, and will be found equal to any of those in Hyde connty; for as we have found by ample observation, the only draw back to a successful cultivation is the absence of soil, or inorganic matter. The necessity, however, of compactness, to give roots a firm hold of the earth is important. Certain kinds of swamp lands remain loose and rather chaffy after they are drained. It is indicative of the absence of soil proper, and when they are exposed to sparks of ignited matter they catch fire like tinder, and burn until extinguished by the exhaustion of combustible matter or are put out by long continued rains.

§ 30. For mechanical analysis of the foregoing, 100 grains were taken and carefully washed:

| | |
|---|---|
| We obtained sand, | 3.00 |
| Very fine soil or sand, | 16.25 |
| Organic matter, | 27.05 |
| | 46.30 |

There is, therefore, a great predominance of very fine inorganic matter in the foregoing, which is rather remarkable; it however, goes to sustain the opinion which has been formed of it; the finely divided matter being in sufficient abundance to last for centuries.

The first soil of which we gave the composition gives, as well be seen, a much larger proportion of the coarser particles of soil. Thus we obtained of:

| | |
|---|---|
| Coarser particles, | 15.00 |
| Very fine, | 41.00 |
| Organic matter, | 18.00 |
| | 74.00 |

The coarser particles consisted of limpid quartz, mixed with felspathic looking particles, the former greatly predominating. Although the extremely fine particles are in part quartz, yet it is highly probable that as felspar is softer and suffers more from abrasion that they are mostly felspathic, and hence, will furnish in the course of time, inorganic elements as food for crops. The fine silica in its condition of fineness is also in a state to be acted upon by alkalies, and thereby become soluble and fitted to be taken into the organism of plants.

The condition of a large part of the inorganic elements is to be regarded in the light of a reason why these soils are so productive in maize.

Another specimen of swamp soil from this district, and from a spot still farther removed from the outer rim than the preceding, gave results somewhat different. It is numbered one, and yielded the following elements on being submitted to analysis:

| | |
|---|---|
| Water, | 75.60 |
| Organic matter, | 16.00 |
| Silex, | 7.60 |
| Peroxide of iron and alumina, | .30 |
| Lime, | .40 |
| Magnesia, | .10 |
| Chlorine, | none. |
| Sulphuric acid, | none. |
| | 100.00 |

The small per centage of inorganic elements in this specimen is due to the great excess of water. If calculated dry, they would amount to about 35 per cent., and each individual element would be increased in proportion. But soils of this composition, especially when connected with water beneath, never become actually dry, but will contain at least from 8 to 10 per cent. of water. This tract, with the composition then as thus indicated, will contain inorganic matter amply sufficient for cultivation. The process of draining in this instance had just begun to take effect, and hence, the amount of water which these lands hold in their natural condition is exhibited.

By mechanical separation of the parts of this soil, it gave:

| | |
|---|---|
| Coarsish soil, mostly quartz, | 1.70 |
| Fine soil, | 7.30 |

Were the fine soil stated in the ratio it will exist after it is perfectly drained and dried in the sun, the amount will be so changed in the relative quantities, that no one will doubt that it can sustain a large growth of corn, or other crops suitable to this class of soils.

The last of this series is No. 3. It consists of earthy matter in a fine state of division, but in which we found a particle of quartz as large as a duck shot, which is uncommon in soils of this description. It contains also partially decomposed sticks or wood. It gave, on analysis, as taken from the tract, with only a slight effect from draining:

| | |
|---|---|
| Water, | 68.80 |
| Organic matter, | 24.91 |
| Alumina and peroxide of iron, | .56 |
| Silex, | 4.50 |
| Carbonate of lime, | .20 |
| Magnesia, | .10 |
| Chlorine, | .07 |
| Sulphuric acid, | trace. |

After exposure to the air for a month it lost water, and hence the proportion of the elements were relatively changed. The soil as first submitted to analysis shows the large amount of water it is capable of holding for some time after the drains have been cut.

The following analysis shows the amount of water lost, which certainly escapes slowly as it has been exposed freely to the air in a dry room for four weeks:

| | |
|---|---|
| Water, | 50.80 |
| Insoluble organic matter, | 22.00 |
| Soluble organic matter, | 10.80 |
| Inorganic, | 16.10 |
| Phos. lime and magnesia dissolved by carb. of ammonia, | 1.20 |

Tried mechanically for inorganic matter, it gave:

| | |
|---|---|
| In coarsish sand or soil, | 8.50 |
| Very fine soil, | 7.50 |

The constitution of this whole tract, so far as the soils collected can be relied upon, prove that it is closely allied to the Hyde county or Matamuskeet lands. There is really no deficiency of inorganic matter, and it is highly probable that cultivation for half a century will improve it. One objection to soils of this description is the loose state of the surface from the presence of undecomposed wood, and hence an insecure condition of maize in a storm of wind and rain. It is highly probable that it will be improved by a heavy roller, or by any measure which will give solidity to the surface.

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## CHAPTER IX.

The Pungo tract. Gen. Blount's plantation. General description of this part of the Albemarle swamp, with its natural growth of timber. Depth and composition of the soils of this section of the swamp. Mechanical separation of the parts of the soil. How the poor soils of this class may be improved. Tyrrell county. The centre of the Albemarle tract highest in the centre.

§ 31. Pungo lake, a small sheet of water, is nearly the centre of

the great Albemarle and Pamlico swamp. From near this little sheet of water numerous sluggish streams depart; some to Albemarle sound, others to Pamlico, and others still, which flowing at first more easterly, drain the centre off towards Hyde county, where finally they take a northerly direction, and flow into Albemarle sound, by Alligator river. Pungo lake appears to be the culminating point of this great tract, where the swell of the crown attains its maximum, and hence, it is here that we should expect to find the most vegetable matter with the least soil.

On the Beaufort county side, or perhaps we shonld say Washington, which is its capitol, we have the north-west rim or margin. The travelled part of this country is along the north side of the Pamlico sound, where the land has the firmness necessary for a road; but a little north lies the drowned lands, which on being traced eastwardly, carry us back to Hyde county.

Many plantations have been reclaimed from the Beaufort side, while the attempts to work successfnly the lands about Pungo, have not been eminently so.

The most successful planter of Beaufort county, and probably of the State, is General Blount. He is the successful pioneer in subjugating the swamps, and probably saw at an early day their great and intrinsic value, and has made a large fortune by their cultivation, and is now the owner of 50,000 acres. It is true, the productiveness of the Matamuskeet lands was indicative of the nature of other swamps, but still it seems to have been held that they were very peculiar and confined, and that planters need not expect equal advantages out of this region, and it has taken time to satisfy the public that rich lands of this class exist elsewhere. What has contributed very considerably to depreciate their value have been the failures to cultivate the poorest tracts, and the management of experiments to determine something satisfactory to owners has often been trusted to incompetetent parties.

§ 32. The specimens which have been submitted to analysis for the purpose of determining the character of the dismal upon its southern margin, or northwestern margin, if we depart from Plymouth, were procured from Gen. Blount's plantation. The examination of so large a field rendered it necessary to select samples from known places. It is not, however, possible to carry such investigations over the whole ground. A life time would scarcely

suffice for this. Neither do we deem it necessary; for, though there are several kinds of soil which possess marked differences in their composition, yet, there would be unnecessary repetitions of facts; for it seems to us there are only a few points which require to be fully established, though they should be placed before those who are any ways interested, in such a light, that these points may be determined by themselves.

§ 33. Gen. Blount's plantation is at Madisonville, 12 miles from Washington, and is located upon the margin of the swamp. The general run of the timber is black gum, of which there is a heavy growth in many places, large poplars and maples, which are usually scattering, and short leaved pines; and when the land falls off in fertility, there is a growth of laurels.

The depth of the vegetable covering, rarely exceeds thirty inches. Its general appearance is much the same as that of all lands of this class, being black, wet and spongy, while in their natural condition. They are based upon a subsoil which is argillaceous, but not so close and compact as to retain the water.

The crops have not been confined to corn. Oats, though not eminently productive, have succeeded very well; the poorest fields yielding from 30 to 40 bushels per acre. In seasons less favorable for this grain, it falls to 20 bushels per acre. The corn crop has averaged forty-five bushels to the acre. Gen. Blount states in a letter published in the report for 1858, that he had raised one hundred and twenty bushels of corn to the acre on a plantation in Hyde county. This result is one which is not surprising, and it shows the lands of this class are fully equal in productiveness to the prairie lands of Illinois, of which we have given some account in a preceding paragraph.

Another fact mentioned by Gen. Blount is of great importance, is that for the forty years, during which he has been a resident upon this class of lands, the health of his family, white and black, will compare favorably with the healthiest locations in Eastern North-Carolina.

Only four specimens from Gen. Blount's plantation have been analyzed.

No. 1. Is a dark soil, and has a depth of twenty inches, resting upon a subsoil with argillaceous matter, but not sufficient in quantity to form an impervious mass. It is intermixed with sand. The

land bore a heavy growth of black gum, with poplars, maples and a few laurels, and in which there was a mixture of the short leaved pine. It bore 50 bushels of corn to the acre, and had been under cultivation three years. It gave on analysis:

| | |
|---|---|
| Silex, | 65.540 |
| Hunic acid or soluble organic matter, | 2.30 |
| Insoluble organic matter, | 23.70 |
| Water, | 6.050 |
| Oxide of iron and alumina, | 4.920 |
| Carbonate of lime, | 0.490 |
| Magnesia, | 0.050 |
| Potash, | 0.003 |
| Soda, | 0.020 |
| Phosphoric acid, | 0.003 |
| Sulphuric acid, | trace. |
| Chlorine, | trace. |

It has a fine drab colored inorganic matter, with a due proportion of oxide of iron and alumina. The proportion of the alkalies and phosphoric acid appear to be small; and yet, the growth of timber indicates a high grade of fertility.

A mechanical separation of the essential parts of this specimen of soil gave:

| | |
|---|---|
| Very fine soil, or sand, | 50.00 |
| Coarser soil or sand, | 20.50 |
| Organic matter, | 26.00 |

It had been exposed to the air several weeks, and had become dry, but soils of this description still retain from six to eight per cent. of water. Mixed with the organic matter we found small pieces of decayed wood, bark, roots, &c. The earthy part was invisible, an important fact, for we may always regard such specimens as containing it in a very fine state of division, and favorable for crops.

No. 2 was taken from an unreclaimed part of the marsh. The depth of soil is two feet. Subsoil contains sufficient clay to check materially the percolation of water, and resists the introduction of the spade. The consequence of this impervious state is, that the surface has always been wet, and more so than in No. 1. The

vegetable growth consists of reeds, which stand very thick. The pines are small and sickly, and intermixed with the former are gall berries and red and white bay bushes. The soil is supposed to have been burnt over in former times, as large stumps of charred pine still remain. After heavy rains the surface is nearly covered with water. It is, however, susceptible of drainage. On submitting this soil to analysis it gave:

| | |
|---|---|
| Silex, | 74.600 |
| Organic matter, | 18.000 |
| Peroxide of iron and alumina, | 3.000 |
| Phosphoric acid, | 0.021 |
| Carbonate of lime, | 0.049 |
| Magnesia, | 0.005 |
| Potash, | 0.040 |
| Soda, | 0.030 |
| Water, | 4.000 |
| | 00.000 |

This specimen was nearly dry before it was weighed. It preserved its water a long time, and after several months exposure to the air, in an open box, it contained 15 per cent. of water. It contained rather fresh and half charred roots, with bark and wood, but its texture was compact, not spongy.

The separation of its parts mechanically gave:

| | |
|---|---|
| Very fine sand, | 55.545 |
| Fine sand, | 15.000 |
| Organic matter, | 18.000 |

No. 3 has been cleared for ten years, and has been regarded as second rate swamp land. The growth of laurels is greater, and fewer poplars and gums than No. 1. For ten years in succession it has been cultivated in corn, and produced, in its prime state, forty bushels to the acre. The last crop was only thirty. A crop of oats followed, with a yield of twenty bushels to the acre. The soil will average 18 inches in depth. The specimen for analysis was taken from a part of the field which is regarded as the poorest, or from that part of the field which produced the poorest oats. It gave:

| | |
|---|---|
| Silex, | 81.600 |
| Vegetable matter, | 12.800 |
| Peroxide of iron and alumina, | 4.100 |
| Carbonate of lime, | 0.020 |
| Magnesia, | 0.010 |
| Phosphoric acid, | trace. |
| Potash, | trace. |
| | 98.530 |

The color of this soil is of a dark gray, and had become dry in the box beside No. 2, which remained wet. It is light and pulverulent, though it forms loose concretions in drying.

The quantity of silex is quite large for this class of soils, and some of the most important elements of growth exist in small proportions. There is quite a contrast between this specimen and No. 1, or between it and the best Hyde county soils.

The foregoing sample of soil is one which would be greatly improved by the use of marl. It has a large stock of organic matter, and hence large dressings, if thought advisable, could be used without injury. The labor and expense of enriching soils of this description is much less than when they are nearly destitute of soil or inorganic matter, and it is no doubt true that all the peaty soils which begin to be deficient in the inorganic elements may be brought up to the best class of soils by the use of marl alone, for in the use of this fertilizer more than one good result is secured. In the first place the necessary elements, lime, magnesia, iron and phosphoric acid are added to it, and in the second place marl consolidates the mass, an improvement which most swamp lands require.

No. 4 has a depth of 3 feet and rests on a sandy clay, and allows the percolation of water. The timber is very large, black gums from one to two feet in diameter at the stump, and fifty to sixty to the limbs, with straight bodies; the limbs form an angle of about 30° to the axis of the trunk. Poplars with large trunks are not uncommon, mixed with maples in keeping with the former as to size and thriftiness, and cypresses, averaging from 8 to 10 to the acre and from two and a half to four feet and a half in diameter at the stump; the bodies are straight, and the limbs form an angle with the trunk of 40°, and first appear at the hight of one hundred feet. This tract is uncultivated. Its soil is composed of:

| | |
|---|---|
| Silex, | 77.56 |
| Organic matter, | 15.400 |
| Peroxide of iron and alumina, | 6.900 |
| Lime, | .500 |
| Magnesia, | .100 |
| Potash, | .019 |
| Soda, | .029 |
| Phosphoric acid, | .062 |
| Sulphuric acid, | .180 |
| Chlorine, | trace. |
| | 101.028 |

The mechanical separation of its parts gave:

| | |
|---|---|
| Very fine sand, | 60.00 |
| Fine soil, | 25.50 |
| Organic matter, | 15.40 |

The sand is not coarse, but rather fine, and (quartzose) of a gray color. It is very uniform in size in all the specimens.

This tract probably contains the best land of the section. It is black in color and contains partially decayed roots, bark and wood. The timber, depth of soil and its composition, indicate a soil probably equal in fertility to any in the eastern counties. The silicious matter is fine, and of a drab color. Portions of this soil, after drying in the air, were exposed to the heat of an oven having a temperature of 300°, and lost 34 per cent. of water.

It appears to be established from many observations and experiments relative to the swamp lands, that much depends upon the fineness of the soil intermixed with the vegetable matter; for when there is a perceptible coarseness of all the particles, the land will not bear cultivation many years. It will be deficient in elements which are always large enough in uplands, as the oxides of iron and alumina. The soil too, will be found to consist of quartz or flint, similar to that of beach sand. This variety dries readily, and is liable to become chaffy, or if the vegetable matter is fine, the quartz soon shows through the white ground in which it is imbedded; where, on the contrary, the earthy matter is fine, it retains moisture and bears the drouths of summer without suffering. In certain combinations of soil elements, extreme fineness

may be a defect; it may be too impervious to the air, and so light as to be blown away with high winds. Such cases belong to that class of soils where the vegetable matter is comparatlvely small. But in swamp soils extreme fineness, instead of being an objection, is an advantage.

§ 34. The high esteem in which swamp lands begin to be held should not blind the eyes of their admirers to the fact, that like other lands, they will show the effects of bad treatment after a while; and it may, indeed, does turn out, that they become at least partially exhausted after several years of cultivation. When it is found that the quantity of Indian corn per acre is steadily falling off, while the seasons are favorable, it is a warning to the planter that he is taxing his land too much, and it requires rest, or some mcdification of treatment.

Experience proves that guano acts admirably upon these lands when they are becoming exhausted, and no doubt the vegetable matter still remaining has much to do with the beneficial effects of this fertilizer.

Marl also acts very favorably, and it is one of those kind adjustments which brings these lands and marl in juxtaposition.

The favorable action of guano must in part depend upon the ready absorption of its ammonia by the vegetable matter, a fact which is well established. There is, therefore, less loss or less liability of losing this important element when used upon these lands, than upon uplands, where the vegetable matter is generally small, rarely exceeding five or six per cent., and often reduced to two or three.

We see, on comparing swamp lands with sandy ones in this respect, especially those of the kind which often occur in the eastern counties that, in the latter, the use of guano is rather precarious, much depending upon seasonable rains or showers. On swamp lands, again, neither guano nor marl are liable to burn the crop.

When, therefore, lands which have a constitution similar to those of Beaufort, Washington and others, it seems to be conceded that they are less liable to suffer from the irregularities of our climate than the best class of uplands.

§ 35. That part of the Albemarle and Pamlico swamp which extends into Tyrrell county, appears to rank only as second rate soil; but it is only upon the Croatan sound that we have made

examinations, and hence we may have formed an erroneous opinion of a part of this great tract. We know that there are lands of this class which are cultivated successfully and with profit, but how they rank, when compared with Hyde, Washington and Beaufort counties, our data are insufficient for forming a satisfactory opinion.

§ 36. The centre of this great tract is higher than the margins, and we believe this phenomenon to be due to a growth of vegetable matter, and it will probably turn out that at the surface there will be a deficiency of soil, or a great excess of the vegetable element. If this conjecture is true it will be liable to take fire from the carelessness of hunters, and even to occur when the common precautions have been taken to prevent it. Much, however, is to be expected from a better drainage than has yet been obtained. When this has been obtained there will be a great change in the upper part or surface, the loose vegetable matter will shrink to half of its present bulk, and if in the early times of the formation soil accummulated with the vegetable growth the surface may undergo so great a change by depression that the roots of crops may be brought within striking distance of the soil below.

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## CHAPTER X.

Bay river District, composition of its soil. The 4th District of swamp lands. The open prairie of Carteret County, composition of its soils, change effected by drainage. Inorganic matter increases with the depth of soil.

§ 37. Bay river district of swamp lands is included between the lower reaches of Pamlico and Neuse rivers, or between their forks as they unite to form Pamlico sound. Bay river is intermediate between these two rivers.

This district is much smaller than the preceding or the Albemarle. It has the same general characteristics; a flat country, with swamps interrupted by hard ground, which generally extends along, and not far from the estuaries of the Pamlico and Neuse.

The only specimen of the Bay river lands, which we have preserved for analysis, cannot be distinguished from those of the other districts. It is separated mechanically into the three distinct parts, and furnishes proportions, or ratios, quite similar to the best swamp lands; thus:

| | | |
|---|---|---|
| One hundred grains gave, of coarsish sand, | 23.0 | parts. |
| Very fine sand, | 17.0 | " |
| Organic matter, | 55.0 | " |
| Water, | 5.0 | " |

§ 38. The partly chemical and partly mechanical analysis, gives a result corresponding to those of the other districts which are known to hold a high rank.

The principal point which requires to be brought out and proved is, the proportion of soil existing in the mass of the peaty matter, inasmuch as when this is proved, it has been found to possess the same complexity of composition as any soil from the midland counties; that is, it is found to contain iron, alumina, lime, magnesia, potash, etc., though like much of the soil of the eastern counties, the relative proportion of silex may be greater. It seems from this fact, and the character of the deposites in all the eastern counties, that formerly, the state of the river currents and other agents, performed the same functions that they now do, and much in the same manner; they transported the abraded materials from the upper country, assorted them, and disposed of them as the same rivers, currents, agents, &c., now do upon our coast.

§ 39. The 4th district of swamp lands, lying between the lower reaches of the Neuse and Core sound, is elongated westwardly and comparatively narrow for its length. It furnishes the same varieties of soil as the preceding, passing from those which rank as number one, to number three, or those which are too poor to hold out inducements to clear them, in the present relative value of landed property. Indeed this country furnishes such a vast acreage of tillable land that even second rate lands will remain uncultivated except when their locations for market are extremely favorable. We ought to take their adaptations into consideration; for certain lands which rank only as second or third rate for corn, or wheat, may pay very large profits if planted with Irish potatoes. Certain

tracts of poor lands answer well for pasturage, sheep husbandry, etc. It is rare indeed, that we can justly say of this or that piece of land, that it is good for nothing. These remarks are applicable to the tract which we propose now to consider. We shall confine our remarks to that part of this district which is included in Carteret county. We have not attempted to give exact boundaries of swamp lands. It would be impossible in the present condition of the State surveys. When large districts are marked upon any ot the best maps, it would be adopting an error to regard their boundaries as correctly drawn. The swamps are connected by strips of narrow belts, and swell out irregularly, and hence, may be considered as forming one tract, but their shape or form is extremely irregular, and most plantations have their swampy parts, though they are principally upland.

§ 40. It is a matter of little consequence, however, whether a tract of this class is large or small; the general characterics will be those of the large areas; their composition will agree, and their qualities will belong to one standard, or, they will rank in the same grade according to the amount of inorganic matter which they contain.

§ 41. The great tract in Carteret, generally known as the open prairie, is a marsh or swamp, mostly destitute of trees; and hence, the area which is exposed to view is more than ten miles in length and breadth. But the entire tract, has an area more than two hundred square miles. In this tract, there is a continuity of swamp, ranging somewhat in condition, depth of mud, and solidity of surface, but it is all swamp in reality. It furnishes a growth of coarse grasses over its whole surface, or that part which is open to the sun. This tract is surrounded by a piney ridge which has a sandy soil and bears moderately large, long leaved pines. But the immediate border is so thickly overgrown with briers, reeds, bamboos, and other ugly bushes, that it is at the expense of a man's coat, pantaloons and shirt, if he forces his way through them. This outside hedge is twenty rods wide in many places, and even wider in others. Since improvements, however, on a small scale have been undertaken by means of ditching, the access to the open grounds is easy and safe.

This tract should be described under two divisions, the outside briery border, and the grassy open part. The first is much the

least in area, but it is of considerable importance, as it is land which has a high intrinsic worth.

We visited this tract in 1852, in April, by the direction of the Board of Education. The time proved very unfavorble for conducting the examination. The prairie was filled with water and the facilities for getting over it, were only clumps of grassy knowles which stood above the water. It was soft and yielding to the foot every where else, and was easily penetrated to a depth of between five to ten feet.

During this visit, we procured specimens of the surface from a depth of eighteen inches. When brought up, they were spongy and black, and consisted mostly of vegetable fibre, undergoing the common changes incident to swamp grounds. But the examination was not satisfactory, and could not be from the circumstances under which it was made. The question, however, for decision was, whether the composition of the soil of the swamp held out encouragements for expenditure for draining it, or if drained, could it be cultivated with profit? The surveys of this great tract prove that it may be laid dry; it is from 12 to 15 feet above storm tide. The drainage is into Core sound and Neuse river, and is higher in the middle than its borders. The largest or heaviest drainage is into the Neuse. The position of the open ground prairie with respect to water access and removal of products is very favorable, and if this tract was under cultivation, all parts of it would find convenient points for reaching the deep waters of this river.

The soil of the rim of the open prairie is richly constituted. On submitting a sample to analysis it gave:

| | |
|---|---|
| Water, | 11.200 |
| Organic matter, | 52.700 |
| Silex, | 32.500 |
| Per oxide of iron and alumina, | 2.000 |
| Carbonate of lime, | 1.000 |
| Magnesia, | .300 |
| Potash, | .073 |
| Soda, | |
| Chlorine, | trace. |
| Sulp. acid, | trace. |
| | 100.063 |

§ 42. This part of the tract furnishes a black vegetable mass from three to five feet deep; it is homogeneous and contains comparatively few fibres in an undecomposed state. By experiment it produced excellent Irish potatoes, and a growth of corn stalks and leaves, which, in consèquence of late planting and inattention, bore no ears. The seed was planted the 20th of June, and the weeds were allowed to have their way, but the result proved that the crop did not fail in consequence of the unfavorable constitution of the soil. When corn is planted in peat destitute of soil it grows to the hight of a foot and then dies. The stalks, however, were well developed and well supplied with leaves, and grew to the hight of 10 feet. Hence, it is probable that had the corn been planted in season and properly hoed it would have borne fruit. However, there never has been much doubt respecting the border soil, its rank vegetation furnishes testimony quite conclusive.

Mechanical separation gave:

| | |
|---|---|
| Coarsish soil, | 7.00 |
| Fine soil, | 25.50 |
| Organic matter, | 52.70 |

It, therefore, contains a large per centage of very fine soil, and which is well adapted to the growth of crops.

§ 43. The piney ridge which forms a border still higher than the prairie has a soil more sandy than the preceding, and is regarded a second rate land of this class. It gave, on analysis:

| | |
|---|---|
| Water, | 2.58 |
| Organic matter, | 8.58 |
| Silex, mostly sand, | 78.20 |
| Per oxide of iron and alumina, | 3.82 |
| Carb. of lime, | 3.80 |
| Magnesia, | .50 |
| | 99.58 |

Separated mechanically it gave:

| | |
|---|---|
| Coarsish sand, | 17.20 |
| Fine soil, | 16.00 |

§ 44. The foregoing furnishes nothing important any farther than the fact that the immediate surronndings of the prairie the soil differs in no respect from the common soils of this region of country. A change, however, is immediately recognised on passing within the piney ridge, especially that of the open grounds.

Since an important drainage has been effected by a ditch about four feet deep, and extending one mile from the outer rim, the ground has settled about 18 inches over an area of about half a square mile. It was near the drained part that our soils were taken in 1852. Upon this part, or the drained part, three small patches of corn were planted last year. The two outer pieces were upon the part from which our first specimen of soil was taken, and in the same piece with the corn, beans, and Irish potatoes were grown which ripened well. The piece of corn upon the open prairie and about three-quarters of a mile from the outer rim was not equal in size and vigor to that nearer the outside; still, considering all the circumstances, the experiment ought to be regarded as successful, though we do not believe this tract adapted to the growth of corn.

From this patch, and from the bottom of the most vigorous corn hill, we took a specimen of soil for examination. It had the following composition:

| | |
|---|---|
| Water, | 21.38 |
| Organic matter, | 60.62 |
| Inorganic matter, | 2.60 |

It can hardly be maintained that so small a quantity of inorganic matter would have sufficed for the existence of corn of the size we found it in September, and the only solution which can be given of the fact is that the roots penetrated to the subsoil which contains a much larger per centage of inorganic matter.

This view is sustained by the character of the soil which appears in the middle of the ditch not more than 10 feet from the place where the corn grew, and about 12 to 14 inches deeper than the specimen just referred to.

Thus the soil of the middle of the ditch, under the vegetable coating, gave on analysis:

| | |
|---|---|
| Water, | 12.08 |
| Organic matter, | 46.22 |
| Silex, | 34.58 |
| Peroxide of iron and alumina, | 2.60 |
| Carb. of lime, | 2.60 |
| | 91.66 |

The mechanical separation of parts gave:

| | |
|---|---|
| Coarse sand, | 27.00 |
| Fine soil, | 11.58 |
| Organic matter, | 46.22 |
| | 82.80 |

§ 45. Not far removed then from the surface soil there is a deposit consisting of organic and inorganic matter in due proportions, and within the reach of the roots of corn and other plants. The soil being light presents no obstacle to their penetration below, and indeed are invited there by a greater amount of moisture since the drainage began. The sand in the middle part of the ditch and elsewhere probably, is distributed irregularly. We find it as it were in nests, but there is still in the vegetable part a fine soil to the amount we have stated. We were unable to procure soil in 1852 from this depth, though in sounding we always found what appeared to be a sandy deposit. Since the surface has settled by drainage, the upper part has as it were diminished greatly in thickness and seemingly in quantity, but it is really only in bulk. It has become compact. The coarse sand is of a granitic origin, as it contains felspar and mica, a fact which holds out an improved prospect of its fertility being lasting.

We would not advise an attempt of raising corn upon the prairie grounds. We believe the Irish potatoe will prove the most profitable crop, especially so long as they find a ready sale at the price of from $1.50 to $2.00 per bushel. Irish potatoes can be raised at a cost of only ten cents per bushel, at which price they become profitable for the manufacture of starch. But so long as they bear so high a price, starch making, though a simple process, would be out of the question. The quality of the potatoe grown upon the prairie is really superior to the northern growth, or to such varie-

ties as find their way to this State, being mealy and entirely free from a strong taste or odor. They would also be employed if cheaper for fattening swine, as they make a superior meat when the fattening is completed by the use of corn meal.

The composition of the soil at the bottom of the ditch differs essentially from the foregoing. It contains :

| | |
|---|---|
| Water, | 4.80 |
| Organic matter, | 6.60 |
| Silex, | 79.82 |
| Alumina, | 2.92 |
| Peroxide of iron, | 1.30 |
| Carbonate of lime, | 3.00 |
| Magnesia, | .40 |
| Potash, | .03 |
| | 98.87 |

§ 46. A result similar to that which is brought out strongly in this analysis seems to be one, which is general, or common to all soils of this class. It is the steady increase of soil in quantity, proportionate to the depth. At the top, it is at its minimum ; in the stratum from one foot to twenty inches below, it has sensibly increased; and near the bottom, it is in quantity equal in amount to the upland soils, though more silicious. There the top of the soil has only between 2 and 3 per cent. of soil ; it is really the ash of the vegetable matter. Eighteen inches deeper, and we find 34 per cent., and at the depth of 4 feet, it has increased to 79 per cent. Considering the character of the soil, we regard these facts as important, for there is really no obstacle to the penetration of roots to this depth when the body of soil is drained. We often find roots penetrating still deeper, and in a stiffer medium by far than this. It is essential, however, that stagnant water should be removed, and that no layers of earth and vegetable matter containing astringent salts be left undrained; and if existing should be neutralized by the use of lime or marl. We may also observe that the organic matter continues to the depth of four feet, but it diminishes about in the same ratio that the inorganic increases, but its presence is important, as it keeps the mass porous, and if air penetrates thus far it is acted upon and furnishes the usual products for the growth of a crop.

But in the middle of the large swamps, the vegetable covering is much thicker than upon the borders, and hence may be, and no doubt is, too thick to permit the roots to reach a bottom, or layer charged with soil. How much deep draining will effect in consolidating the surface after a sufficient lapse of time for drying and increasing its solidity, has not yet been determined by trial. We have found in some samples 100 per cent. of water remaining after the soil had been exposed two weeks to the air. While vegetable matter is thus soaked, or permeated with water, its bulk is greatly swollen; and hence, when removed by thorough draining, and it will also shrink excessively and probably not occupy more than one third of its former bulk; its diminution of bulk, will no doubt in many cases render the soil accessible to the roots of plants.

In the Albemarle district and adjoining the tract, and indeed forming a part of it, there is an open prairie quite similar to the Carteret in general appearance. It lies towards Pungo lake, or a little to south-east of the creek. It is called the burnt lands from the common opinion of the inhabitants, that it has been burnt over, when its timber was destroyed. It is regarded also as having been prior to this period a juniper swamp. At present its vegetable productions are limited to a few scattering bushes which do not interfere with a wide view over the whole field for many miles in all directions. To the eye the surface soil scarcely differs from that of adjoining productive tracts. But the prevalent opinion is that it will prove a barren field after a few inferior crops are harvested.

We have only separated the parts of the soil taken from near the surface. It is black and slightly gritty between the teeth, and evidently consists of vegetable matter to a great extent.

On being mechanically divided, it gave:

| | |
|---|---|
| Coarsish quartzose sand, | 1.70 |
| Fine, or very fine soil, | 4.10 |
| Vegetable matter, | 27.2 |
| Water, | 67.0 |
| | 99.030 |

This separation gives a small per centage only of soil, but as the specimen was fresh from the field, and contained a large propor-

tion of water. The 67 per cent. which it holds before draining, will afterwards be diminished about two-thirds; and hence, the quantity of fine soil will be relatively increased. We should also take into the account the increase of soil in depth, and within striking distance of the roots of crops, which will come in aid of the planter. Without spending time in a conjecture whether the burnt district can be profitably cultivated, as it is, it will aid us in making up a judgment before hand to compared it with another on its growth of timber in its vicinity, and whose soil is externally identical in character. It is a tract situated near or upon McRae's canal. This tract is remarkably heavily timbered. The trees consist of black and white gum, cypress, the long and short leaved pine here and there, and all are large. Among them is the red maple, which is regarded as a sure indication of a productive soil, when associated with the foregoing.

The composition of this soil, as determined mechanically is as follows:

| | |
|---|---|
| Coarsish quartzose sand, | 3.50 |
| Fine soil, | 5.00 |
| Water, | 70.80 |
| Organic matter, | 20.70 |
| | 100.00 |

It appears that a soil of the foregoing composition with only 8.50 per cent. of inorganic matter bears large forest trees and those which all regard as indicative of a productive soil; and indeed, which has proved to be such when brought into cultivation. The differences then between the two soils, the burnt lands, and the canal tract, are only slight; and it appears to us, that an attempt to cultivate the former is warranted by all the facts which have come to our knowledge. The differences do not seem to be so wide, at any rate, that one should be set down as barren and worthless, while the other, is regarded by all as an exceedingly valuable tract.

The same remarks apply to the open prairie of Carteret, though not so forcibly, yet we have sufficient indication that it will be productive of a number of crops when it is properly drained and attended to.

# CHAPTER XI.

Composition of soils towards Beaufort. Composition of Mr. Sefton's swamp land. Adams creek soils, Craven county. Dover swamp Craven county. Its hight above Newbern. Composition of its soil.

§ 47. The open prairie is at present a wilderness, but towards Beaufort many plantations are located upon the main road leading to these lands, and which include portions of it which are regarded as highly valuable. Several tracts, from four to six miles from Beaufort, have been examined.

Of these, Mr. Sefton's furnishes probably as fair a representation of the character of this part of the Carteret swamp, as any. The timber is all large and thrifty, consisting of cypress and black and white gum, mainly, with water oak and the long and short leaved pines. The part from which the sample of soil was taken has been in tillage two years, and had at the time a crop of corn unharvested, which from estimation by the owner, would give fifty bushels to the acre. It is black, but shows sand within one foot of the surface. The specimen taken was from a depth of eight inches, and from the corn field alluded to. It gave, on analysis:

| | |
|---|---|
| Water and organic matter, | 20.000 |
| Silex, | 73.300 |
| Peroxide of iron and alumina, | 4.400 |
| Carbonate of lime, | 1.700 |
| Magnesia, | .170 |
| Potash, | .086 |
| | 99.656 |

The sample had become dry by exposure to the air for three months. It contained a trace of ammonia in 1,000 grains. Upon a part of this tract which had been in cultivation for several years, fine looking cotton was growing. It was late planted, but the trial was regarded as highly successful, and it will probably turn out that the best soil for cotton are those of the half worn ones which originally were rich in vegetable matter. On such lands there would be a great saving in fertilizers. Mechanical separation of its parts, gave:

| | |
|---|---|
| Coarsish sand, | 43.2 |
| Fine soil, | 30.0 |

The coarsish sand is all quartz, and it is visible in the dry specimen, and is easily detected in the wet, by its gritty feel. Still, there is a stock of fine matter sufficient for all the wants of vegetables. The vegetable matter, as usual, increases in depth towards the central part of the swamp, and the growth of cypress and black gums is also greater in this direction than upon the margin.

§ 48. Immediately opposite to the section of land which has been drained, and the soils of which have been under consideration, is Adams creek, in Craven county. The principal branches of Adams creek rise in the crowning part of the open prairie, and if prolonged would interlock with the branches which form the North river on the Beaufort side. We have the soils at this time from the banks of Adams creek, and have made several analyses of them to that extent which will serve as a basis on which we may found a judgment of their merits.

We did not deem it necessary to make a minute analysis as in other soils, and it seemed sufficient to do enough to enable us to make a comparison of their qualities with those of the North river as well as those from other swamp lands. The first is evidently a mixture of organic matter with fine and coarse sand and other elements brought out by analysis. It gave:

| | |
|---|---|
| Organic matter, | 29.00 |
| Silex, | 54.80 |
| Alumina and iron, | 4.40 |
| Carbonate of lime, | 0.35 |
| Magnesia, | 0.13 |
| Water, | 11.00 |
| | 99.68 |

A mechanical separation gave:

| | |
|---|---|
| Rather coarsish sand, | 43.00 |
| Fine soil or sand, | 28.40 |
| Organic matter, | 29.00 |

This soil had become dry by exposure to the air, and much less

water was obtained than is usual from swamp soils, and where there is as much inorganic matter as in this specimen, the drying by common exposure is more complete and rapid than where it has less. The sand is white quartz. It appears that the sand of the open prairie of Beaufort is coarser than that of the Albemarle district, but it is intermixed with a quantity, 16 per cent. of fine material.

Another soil from Adams Creek differs from the foregoing, as will be seen in the larger quantity of sand and less vegetable matter. It is gray and gritty, and harsh to the feel, and was taken from beneath the covering of organic matter. On submitting it to analysis, it gave:

| | |
|---|---|
| Water, | 6.30 |
| Organic matter, | 8.00 |
| Silex, | 82.58 |
| Peroxide of iron and alumina, | 2.82 |
| Carbonate of lime, | .50 |
| Magnesia, | .13 |
| | 100.03 |

We have been able to obtain a small amount of potash in all the soils we have examined from the swamp lands. It is diminished to a small fraction wherever the sandy element is so large. A mechanical separation of its parts gave:

| | |
|---|---|
| Coarse sand, | 56.2 |
| Fine soil or sand, | 29.0 |
| Organic matter, | 8.0 |
| | 93.2 |

In another specimen, the organic matter was only 3.22, water 6, silex 88.78, alumina and peroxide of iron 2.60.

The Adams creek district seems not to want inorganic matter at all; they have, indeed, rather an excess, and too little vegetable matter. To account for this fact, it seems that the Craven side of the great marsh must have been nearer to the source from whence the sandy matter was derived, and though none of it is what would not ordinarily be regarded as coarse sand, yet it is coarser than

that of North river. There may have been a direct communication with the Neuse in former times, and by means of that communication the sandy matter was supplied. The coarse is always nearer the source from where it came. The fine is transported farther and is deposited slowly; facts which may be witnessed in all heavy showers where currents are formed with sufficient force to move the loose materials upon the surface.

§ 49. The Dover swamp, lying north of Newbern, in Craven county, is about fifteen miles long. It is about 60 feet above Newbern, and 30 or 35 above Kinston.

So far as its character is shown by the roads which pass through it, it is a poor tract.

A single representative only of its soil will be given in the following analysis. The soil is black, and to the eye it may be regarded as ranking high in the scale of merit, but where the black vegetable mold is cut, and has been exposed to washing by rains, they have brought out mechanically its characteristics. The vegetable matter is mixed with a white marine sand, which is exposed upon the face of the cut; an exhibition of this kind is never witnessed in soils suitable for cultivation. An analysis of a soil representing the Dover class, gave:

| | |
|---|---|
| Water, | 2.71 |
| Organic matter, | 25.22 |
| Sand, | 70.50 |
| Peroxide of iron and alumina, | 0.76 |
| Carbonate of lime, | 0.01 |
| Magnesia, | trace. |
| | 99.20 |

The specimen had become dry by exposure to the air in paper, and hence, the small quantity of water. The sand is white, and nearly pure quartz, and only a small per centage could be dissolved out by the action of muriatic acid. When this specimen is compared with those of the Albemarle swamp, which seemed to lack inorganic matter, a great difference is easily discovered in the Dover swamp representative; the water was reduced to the lowest standard; it was much drier than it ever will be by draining. In the Dover representative there are really only two elements, white

sand and vegetable matter. If water is added, the sum of the three amounts to 98.43, leaving only 1.57 for the active or soluble elements, and still the Dover swamp is covered with vegetation, though it is not vigorous and healthy. It is no doubt, supported in a great measure, by the subsoil and the elements derived from the atmosphere.

If a farmer, however, should drain and put it requisition for corn or wheat, it would not answer to the call. It is not to be understood that we speak thus confidently of the whole tract, and it is highly probable that rich places exist. The most we wish to inculcate is that where the soil consists of vegetable matter intermixed with white or gray quartz sand, there is but a small ground for hope that the tract will pay the expense of drainage. The foregoing views as intimated in the foregoing paragraphs receive support from the consideration that .76 per cent. of per oxide of iron and alumina cannot furnish for a lapse of years sufficient phosphoric acid to sustain the cereals, it is at least evident, that the available matter for divers crops is extremely small. The practical per centage of important elements, cannot exert a chemical or mechanical influence upon the organic matter.

We confess, however, that we do not know the nature of the subsoil, it will probably turn out that the forest trees derive their support from the stiff subsoil on which the silicious vegetable matter rests. There are many points in which the swamp soils differ from the true peat of the Northern States and Canada. A very reliable analysis of a kind of peat found in Canada by Mr. Hunt of the Canada Geological survey may be cited. Thus, Mr. Hunt found 6.75 per cent. of ash, and it should be observed that it is not soil, as in most cases of the swamp peat of the South but a true ash of the vegetable matter, and hence, its composition must partake of that of an ordinary ash ; and hence, it is found to consist of large per cents., viz : of carb. of lime 52.41 ; sulphate of lime 15 ; sulphate of potash 0.60 ; lime and magnesia as silicates, &c., to the amount of 13 per cent. The peaty soils of the South, or certainly of North-Carolina consist of intermixtures of fine inorganic matter to a large extent, and though the top is essentially vegetable matter, yet the soil increases continually, or if the areas as indicated before had communications with rivers from which they received sediments, whereas, in the North the peat is formed in isolated basin-shaped

excavations, which have been filled up by the growth of moss, or sphagnum, etc., and were of course separated from rivers or streams bearing sediments from a distance.

§ 50. The Onslow and Jones swamp, which appear to be connected with the great Carteret open-ground prairie and swamp, has an area of over one hundred square miles. The White Oak river rises in it, together with New river, both of which empty into Bogue sound, or Bogue and Stumpy sounds. Short branches rising in this tract, fall into the Trent. The slope is mainly towards Bogue sound. This great tract is easily drained, being formed upon comparatively high ground. Portions of it have been under cultivation, and the produce in corn has been from ten to twelve barrels per acre. Upon the branches of the White Oak the timber is large, consisting of poplar, cypress, black and white gum and red maple. Other parts are covered with reeds which furnish subsistence to stock during the winter. The surface of the swamp is more or less interrupted by dry islands, which bear large long and short leaved pines. White oaks abound of a large size, where it is not too wet. Some of the islands, as they are called, have a light sandy soil, and seem to have been formed by the action of water. The only canal for drainage which we have inspected, was cut by Mr. Franck, of Onslow county. It crossed a part of the tract called the White Oak desert. This, on being cut one mile, gave a water power of about twelve feet. Its cost was fifteen cents to the cubic yard. The depth of soil varies from one to twelve feet, the depth increasing towards the central part of the tract.

The general characteristics of this swamp are the same as those which have already received attention. The composition, as determined by analysis, may be stated as follows:

| | |
|---|---|
| Silex, | 60.00 |
| Organic matter, | 25.00 |
| Peroxide of iron and alumina, | 11.050 |
| Phosphoric acid, | 0.312 |
| Carbonate of lime, | 1.500 |
| Magnesia, | 0.300 |
| Potash, | 0.010 |
| Soda, | 0.020 |
| Silicic acid, | 0.100 |

| | |
|---|---|
| Water, | 2.713 |
| | 100.983 |

The machanical separation of parts gave:

| | |
|---|---|
| Coarsish felspathic sand, | 27.00 |
| Drab-colored fine soil, or sand, | 45.00 |
| Vegetable matter, | 25.00 |

The soil was dry by exposure in paper, and to the air.

The felspathic sand is coarser than that of any part of the Albemarle district. The quantity of fine soil, and of lime also, is large, and the elements of fertility appear to be sufficient to constitute a good composition for cultivation.

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## CHAPTER XII.

Swamp lands of New Hanover and Brunswick counties, their composition with remarks.

§ 51. The fifth swamp district is in New Hanover county. It is formed by the Holy Shelter swamp and Angola bay. They both are elongated tracts, and drain into the eastern branch of the Cape Fear.

We find the composition of the soils of the swamp lands of New Hanover county to correspond with those already given. Thus a specimen gave, on analysis:

| | |
|---|---|
| Organic matter, | 7.700 |
| Silex, | 86.000 |
| Per oxide of iron, | 1.000 |
| Alumina, | 4.000 |
| Silicic acid, | .300 |
| Chlorine, | trace. |
| Sulphuric acid, | trace. |

| | |
|---|---|
| Potash, | .077 |
| Carb. of lime, | .320 |
| Magnesia, | .105 |
| | 99.502 |

Mechanically separated it gave, in parts:

| | |
|---|---|
| Felspathic sand, | 32.0 |
| Finely divided soil, | 49.0 |
| Organic matter, | 7.7 |

The specimen was well dried before analysis, and was black, but consisted of vegetable matter in small quantity only, and in which the soil was distinguishable. Still it has been proven productive.

§ 52. A fact which will perhaps strike the attention of a chemist is the small quantity of iron which exists in all the swamp soils. It is not only, as we have before stated, in the condition of a protoxide, but it is in a less proportion than in upland soils. How much influence this quantity of iron may have upon vegetation, to diminish the chances of a healthy growth, cannot be determined before hand. Iron is no doubt an important element in soils, though we believe, upon the whole, that even in the swamp soils it will be amply sufficient to meet the wants of crops.

So long as these tracts are undrained, charged with water, the iron will remain in the condition of a protoxide. When drained, and air replaces the water, it is at least partially changed, and becomes more highly oxidated and is, constantly undergoing changes by which the amount of oxygen is variable, especially when in contact with a large amount of vegetable matter.

§ 53. The sixth swamp district is confined to Brunswick county. It is round or nearly so, and presents a very uniform outline, but its interior is studded with islands, and the swampy part incloses them entirely or they are connected to others by narrow necks of hard ground. This swamp lies low and its perfect drainage is questionable. We have not been able to obtain an examination of surveys which were made years ago. It furnishes a vast amount of cypress for shingles. The timber is well set, large and thrifty, and

the indications for fertility are the same as those which have been already stated.

The composition of the soil supports the views just expressed. A sample on analysis gave:

| | |
|---|---|
| Organic matter, | 37.50 |
| Water, | 15.80 |
| Silex, | 35.35 |
| Peroxide of iron, and alumina | 10.50 |
| Carb. of lime, | 1.45 |
| Magnesia, | 0.15 |
| Potash, | 1.10 |
| Soda, | 0.15 |
| Sulphuric acid, | trace. |
| Chlorine, | trace. |
| | 100.00 |

A mechanical separation of its parts gave:

| | |
|---|---|
| Coarse sand, | 2.10 |
| Fine soil, | 33.25 |
| Organic matter, | 37.50 |

It should be stated that this soil contained a greater quantity of half decayed wood sticks than usual, and hence, the proportion of soil is comparatively less than it would have been by rejecting this kind of vegetable matter.

§ 54. Large tracts of this swamp are laid under water by dams which overflows the high way or roads and the traveler is forced to drive his team through water from a foot to 4 or 5 feet deep. The tide of the Cape Fear sets up the creeks some twelve miles from their mouths, which is indicative of a flat country to within a short distance of their origin.

The subsoil is often too stiff for easy cultivation, or the penetration of roots. It approaches in composition and consistence a brick clay. Thus the silex amounts to 83 per cent. with 21 per cent. of organic matter, and with only traces of lime, magnesia and potash. It is probably as in other cases variable in composition.

Another specimen of the Brunswick and swamp soil furnished by Mr. H. J. McNeil, gave:

| | |
|---|---|
| Water, | 8.000 |
| Organic matter, | 34.000 |
| Silica, | 45.470 |
| Peroxide of iron and alumina, | 10.490 |
| Carb. of lime, | 0.490 |
| Magnesia, | 0.490 |
| Potash, | 0.581 |
| Soda, | 0.326 |
| Sulphuric acid, | trace. |
| Chlorine, | trace. |
| Silicic acid, | 0.580 |
| | 99.997 |

The composition of this sample indicates as high degree of fertility as the Hyde, Washington or Beaufort counties.

While analysis furnishes very satisfactory results, it is not to be forgotten that the tracts adjacent may be less so, and indeed, not productive at all. Where changes in the kind of timber are apparent, passing from the cypress, gums, populars and maples, etc., to bays, gall-berry, especially if accompanied by a dwarfed condition, it is an indication that the soil has changed, or the conditions have passed from a favorable, to a less favorable one, and though the change may possibly be due to influences which deep draining may remove, yet, in a majority of cases, it is due to the constitution of the soil. This should be examined, and tested in they way we have proposed.

§ 55. In a few wet districts we sometimes meet a peculiar soil, which is, as the people say, salt; but which really never contains but a little chloride of sodium, or common salt. It is a black vegetable substance, in part charged with the astringent salts of iron and alumina. We are induced to speak of this product because we have seen it from three different parts of the eastern counties, in Weldon, near Tarboro' and at Mosely Hall, in Lenoir county. The specimens have the same characteristics, though that from near Weldon was obtained from a depth of 70 feet. We communicated with those interested at Weldon and Tarboro', and have not preserved a statement of results. The specimens from a swamp at Mosely Hall will require a brief notice; though they deserve a full analysis, yet time will not permit us now to enter into details.

The substances, which are really swamp products, are black, with an astringent ferruginous taste. If applied to crops, or if seed are planted in it, they are of course destroyed.

The black astringent substance contains, in 100 parts:

| | |
|---|---|
| Water and vegetable matter, .................... | 11.70 |
| Silex or sand, ................................ | 82.30 |
| Protoxide of iron, ...................... | 1.52 |
| Alumina, ...................................... | 1.82 |
| Carb. lime, .............................. | 0.80 |
| Sulphuric acid, ............................. | 1.61 |
| | 99.45 |

The surface of this vegetable matter is crusted in dry weather with this astringent salt. If this substance were in great abundance it would be an excellent material for composts, notwithstanding it is now poisonous in composition. Mixing lime or marl with it will decompose the present salt and form gypsum. This substance too, is adapted to use in stables, or any place where ammonia is generated, and escapes into the air. Sulphate of ammonia will be formed, or even the vegetable matter itself as it is absorbative, will attract and retain ammonia, but indeed as it is with this salt, it is an admirable material to spread over the refuse of stables and yards where noxious odors escape and which are always we believe compounds, containing ammonia or sulphur or both.

From this swamp deposit we have obtained phosphate of iron, a product which we suppose may have been formed from decomposed animal matter; it is rare one and may be distinguished from other minerals by its beautiful blue color.

Another product of this swamp we are inclined to regard as a compound of phosphoric acid, lime, etc., but we are still in doubt respecting its true character. It is white, inclined to chrystallize in radiating forms, and is sometimes a white, soft substance, and in others quite a hard concretion, assuming a cylindrical form. It is intermixed with grains of quartz, which are foreign particles. It gave, on analysis:

| | |
|---|---|
| Water, ...................................... | 4.2 |
| Organic matter, ............................. | 4.0 |
| Silex, or insoluble matter, ..................... | 59.0 |

| | |
|---|---|
| A substance resembling alumina, | 28.0 |
| Carbonate of lime, | 4.82 |
| Magnesia, | 0.10 |
| | 99.92 |

The white substance resembling alumina, we suppose may be a compound with phosphoric acid, but we have not the proper tests to determine fully its composition; that it is not alumina, is proved by the fact, that though a part of it dissolves in water, yet the precipitate from the potash solution is fused at once in the flame of the blow pipe. If a phosphate exists in quantity, it is a valuable substance; if not in quantity, it is a very interesting one for the mineralogist. A test for alumina is the production of a blue bead with nitrate of cobalt in the flame of the blow pipe. There is a tinge of blue, when thus treated, but the blueness is not strictly that which is common to alumina. These several products were received from Mr. Parrott Mewborn, of Lenoir county, who obtained them in draining a swamp. The foregoing products are the most important, but another which is excessively sandy and brownish black, we have analyzed. It contains:

| | |
|---|---|
| Silex, | 91.0 |
| Water, | 2.1 |
| Organic matter, | 4.5 |
| Peroxide of iron and alumina, | 2.75 |
| Carbonate of lime, | trace. |
| | 100.35 |

Compounds having the foregoing composition are worthless, and seem to have acquired the vegetable matter as a debris, and not from a growth of vegetables upon the spot.

## CHAPTER XIII.

Gall berry lands, and their composition. The Savannah lands and their characteristics and composition.

§ 56. The gall berry lands, as they are called, are a species of swamp, but their characteristics cannot be subjected to the exact rule of the carpenter, nor the legal measure of the grocer; they refuse to be subjected to specific technicalities, though they have certain common characteristics. All lands are not *gall berry*, because the gall berry has taken possession; neither are gall berry lands all composed of stiff clay; some are sandy, with black vegetable matter concealing it, while uncultivated or unbroken. Gall berry lands are level tracts, composed of wet and sandy argillaceous matters, or wet sandy, with black vegetable mold intermixed, and with only small fractional parts of the money elements contained in them in either case.

They seem to have been formed by denudation, by the action of the waves of the sea, by which the best part of a soil, the top, has been carried away, as a stratum of stiff, incorrigible, sandy and ferruginous clay beneath. Over certain areas subsequent to denudation, sand has accumulated along with a coarse vegetable growth, as water grasses and the like; in fact, a formation went on accumulating like the best swamp lands, but the material was a quartz sand, containing only traces of the nutritive elements. In the other case, a formation, though slowly building up now, began with the process of filling up very recently, and the bottom clays exposed by denudation; still, from the top or surface the dwarfed vegetation springs from this incorrigible sandy clay, which is poorly mixed, coarse and closely compacted, so as to hold water about as well as a wash bowl. By evaporation in summer, and a slow leakage, these lands get dry by the middle of July or the first of August, and then they may be traversed, but they are liable to become wet by heavy showers, when by the same processes they again may become dry. In this condition of the soil and surface the inducements are not sufficiently weightly to tempt the owner to drain them, for the purpose of testing their qualities for crops of the cereals, or the less expensive products, the root crops, to

which they are not really adapted. Like other species of land, we find them variable in composition, but uniformly with a level surface, and so close that water stands upon them until it evaporates.

Their relative position is westward of the kinds of swamp which have been described; though lands answering to the gall berry occur in patches in all parts of the eastern counties with variable aspects, but always wet, level and with a dwarfed vegetation.

Their chemical constitution gives two extremes; the black, sandy vegetable mold, and the stiff, sandy, argillaceous bottoms. The former is often mistaken for good swamp soil; the latter, never. The vegetation is much the same in both; coarse water plants, a few reeds in favored places, particularly on the banks of streams, small, short and long leaved pines; but the whole aspect of the vegetation is that which arises from a short allowance of food, and exposure to cold bottoms beneath, and a chilly atmosphere above.

The silex in all the kinds of gall berry lands is large, the soluble alumina and iron, small—and the other elements in small fractional quantities.

Thus in a specimen from Sampson county, we found:

| | |
|---|---|
| Water, | 3.09 |
| Silex, | 88.40 |
| Organic matter, | 4.20 |
| Peroxide of iron and alumina, | 2.92 |
| Carbonate of lime, | .02 |
| Magnesia, | .01 |
| Potash and soda, | trace. |
| Phosphoric acid not perceptible, | .00 |

But medium results are obtained by cultivation when these lands are well drained; but, as it costs as much for draining the lands as better ones, it is not often done. The specimen had become dry by exposure to the atmosphere.

A mechanical separation gave:

| | |
|---|---|
| Coarse sand, | 38. |
| Fine soil, | 50.10 |
| Organic matter, | 4.20 |

§ 57. *The Savannah lands*, differ from the preceding in many important particulars. They are to the eye, dead level tracts, open to the sun and bordered by clumps of trees irregularly planted so as to have open spaces either leading to similar tracts or into the depths of a forest. They are now usually covered with broom grass, and appear rather barren in winter, but in the spring if the dead grass is burned, they become green and pleasant. We have no authentic history or tradition which can be believed in all respects, in regard to their origin. But they really are miniature representations of western prairies, and probably originated by the action of similar causes.

When a certain kind of soil has been forest planted, it continues in forest for centuries, unless some cause destroys the root and branch, as fire or water; and when destroyed and opened to the sun a thick coating of grass covers the ground so perfectly, that the seeds of forest trees are deprived of the necessary stimulants to germination, or if they germinate a repetition of destructive agents again occurs, till all seeds at or near the surface have germinated and have been destroyed. Grass ultimately gets full possession; and though in the general it appears only as grass, yet if watched carefully, it will be found that the grasses have been changing, or a natural rotation has taken place; the rule of exchange being a succession of grasses from the better to the worse, by which we have ultimately in this climate broom grass, an unmistakeable index of an exhausted soil. This view, however, is sustained only when the products of vegetation are taken away. Combustion of the surface materials, followed by winds which transport the light ash far from the field upon which the plant grew which produced it, is an exhausting process. Forest fields when once exposed to the sun by the destruction of their pines, oaks and hickories, are directly in the road to a prairie, or savannah formation; and when the latter is formed, it becomes as permanent as a forest. As it regards their origin, we incline to the theory, that fire has been the direct instruments concerned, and is still more or less active, in preserving these tracts in a stationary condition. The water theory, is less intelligible than the fire theory; the latter explains all the phenomona as we think better than the former.

The soil of the savannahs is fine, yellowish and compact, not unlike a brick clay, and so far as we have observed, contains by far

less coarse sand. It is a homogeneous soil, in which respect, it differs from the gall berry, and it being fine, compact, deep, and still wet, though not a swamp at all, it still holds always too much water for the cultivation of the cereals. The land is cold; a term undoubtedly applicable to this class, in which respect, it differs from the prairies of the west. It differs also from the swamp soils in the absence of vegetable matter, and from the uplands by compactness and firmness of material, and hence too the explanation of the fact, too cold and moist, for the cultivation of the cereals or even of root crops.

The specimen of soil which has been examined was taken from a savannah in Craven county, which is being put into a state for cultivation, and which is owned by Mr. Wood. The Atlantic railroad passes through it. These lands in Craven county, though not so extensive as those of New Hanover, still seem to possess the same characterics. We cannot affirm that there are not many varieties of savannah lands, still, there are good grounds for believing that they possess a greater uniformity of composition than the swamp or gall berry lands.

The savannah soil of Craven, on being submitted to analysis, gave:

| | |
|---|---|
| Water, | 4.00 |
| Humic acid or soluble organic matter, | 2.00 |
| Insoluble, | 1.70 |
| Phosphoric acid, undetermined, | |
| Silex, | 80.590 |
| Silicic acid, | .100 |
| Alumina, | 7.000 |
| Peroxide of iron, | 3.400 |
| Carbonate of lime, | .600 |
| Magnesia, | .176 |
| Potash, | .098 |
| Chlorine, a large, | trace. |
| Sulphuric acid, | trace. |
| | 99.664 |
| Ammonia, | .0387 per cent. |

The specimen was dried in the air previous to analysis, it therefore does not represent the quantity of water held by the soil in its ordinary condition.

The chemical constitution of the savannah lands appear to be well composed for durable cultivation. They will require deep draining and the time required for the escape of water will undoubtedly be twice as long as that necessary to drain ordinary upland soil, in consequence of the fine state of division in which the materials exist, and their natural affinity for water. When drained and dried, we have reason to believe that they will become good wheat or cotton lands.

# APPENDIX,

Containing brief descriptions of the mineral springs and well waters which occur in and about Raleigh.

§ 58. At numerous places in Wake and the adjacent counties several springs have been discovered which are entitled to the appellation of *mineral waters*. Frequent inquiries have been made by letter relative to them, and in several instances these waters have been sent to me for analysis. These requests have been complied with so far as it seemed to be necessary. In most cases, however, when the general character of the water was known by taste, or by its behavior on standing twenty-four hours, I have merely made a qualiatative examination. The water in this neighborhood, or in the town of Raleigh, are all chalybeates, and though they appear to be weak, or contain a small amount only of mineral matter, yet it is sufficient for medical purposes; for if the quantity was larger, it would be more disagreeable to the palate, less would be drank, and it would both affect the head and produce a feeling of tightness across the chest. The quantity of mineral matter is therefore well adapted for use in all cases where chalybeates are useful. An essential condition for the salutary influence of chalybeates is, their solution in a large amount of liquid matter. It insures their absorption into the system, and thereby favors their specific influences, much more than if they were in a concentrated state.

The well waters of Raleigh, which are used for drinking and cooking rank with as much propriety in the class *mineral waters*, as the springs referred to. They differ, however, from them in the absence of iron, or if it exists, it is but *a trace*, and in the presence of chlorides, which exist only in traces in the mineral spring waters. How much influence impure well waters have upon the health of a community is not well determined. But it is well known that to strangers the common waters of a locality are frequently highly injurious, and it is probably true that the purer the water for common use, especially for drinking the better it is, and there is very little doubt that the best water which can be procured for family use, is *rain water*, collected and preserved in filtering

cisterns. In summer it would be warm, but cooled with ice it becomes a luxury.

There is a great uniformity in the composition of the spring waters of this description; the constant differences being a variation in the amount of solid matter dissolved in the water. They belong to the class known as *chalybeate* waters, which contain iron as the most active and important element. Such springs are readily recognized by the yellow or ochreous deposit along the line of flow.

They are limpid or perfectly transparent when they first issue from the ground and when first bottled, but on standing 24 hours, a yellowish sediment falls down consisting of iron, lime and magnesia. This takes place in consequence of the loss of carbonic acid, the matter in solution being retained by an extra atom of carbonic acid, and hence while the salts are held in solution they are bi-carbonates. When the water is exposed to the air the feeble affinity of this extra atom of carbonic acid is such that it soon escapes and the remaining compound in the water is no longer soluble, and hence, is deposited in a powder. A tumbler of those waters standing in the open air shows the escape of a gas which is carbonic acid. When the fresh water is shaken with a solution of red cabbage changed to a tinge of green by ammonia or an alkali, it becomes purplish again by the carbonic acid which is escaping.

It is claimed that some of the springs contain sulphur; those which have been subjected to the action of basic acetate of lead, have scarcely a perceptible effect upon this delicate test. Silver vessels which have been used many times become slightly tarnished in certain spots. Hence, it is possible, sulphuretted hydrogen escapes in exceedingly minute quantities.

The springs usually flow out of banks of gravel and sand in place, and which was derived from granite or gneiss. These banks are more or less ferruginous, but in the best waters they probably flow from the granite, and thence percolate through the soil.

Composition of some of the waters of these springs:

§ 59. *Carter spring*, at the garden, one mile and a half from town. The whole amount of solid matter held in solution in a gallon of water is 16.72 grains. It consists of chloride of lime, organic matter, bi-carbonate of iron, lime and magnesia. In all cases, the organic matter is in the condition of humic, crenic and apocrenic

acids, which are also in combination with the mineral matter. It contains also silicic acid.

The *Ingleside spring*, two miles east of Raleigh, is in a fine grove, and fine drives might be cut out by opening roads, or fine walks, as they would be shaded by avenues of trees.

This spring contains solid matter, about 15 grains to the gallon, consisting of organic matter, iron, lime and magnesia. The chloride of lime was not tested for, but as it is usually present, so probably it is in this water. Its use has had a beneficial effect upon invalids in several instances.

The analysis of the spring upon Mr. Boylan's land, was not preserved; it scarcely differs from the foregoing in the amount of solid matter, to the gallon. The water is pleasant to drink, and is peculiar in its taste.

The water of a spring in Franklin county resembles also the foregoing. One pint of this water contains:

| | |
|---|---|
| Iron, in combination with carbonic and organic acids, | .27 |
| Lime, | .34 |
| Magnesia, | .10 |
| Organic matter as a whole, | 2.13 |
| | 2.84 |

To the gallon 22.77 grs.

The Dodd spring has a temperature of 60°, air being 78. The solid matter in a gallon amounts to 16 grs. In a pint it contains:

| | |
|---|---|
| Organic matter, | .90 |
| Iron in combination with organic matter, | .40 |
| Carb. of lime, | .24 |
| Carb. of magnesia, | .10 |

Besides the foregoing, we obtained both the chlorides of lime and magnesia, the latter in a large trace. The Dodd spring differs from the Franklin county spring in containing less organic matter, and hence, it is that the iron in it, is more distinct to the taste.

The yellow powder deposited from mineral springs has a complex composition. It consists of humic acid, crenic and apocrenic acids in combination with the iron, a portion of the carbonic

acid having escaped. The two last acids are detected by the action of acetate of copper upon the alkaline solution of this ferruginous deposit. There is no doubt, also, that phosphoric acid is present in the compound.

§ 60. The wells of Fayetteville street deserve a place among mineral waters. They differ from the springs simply, in the absence of iron. The well at the corner of Fayetteville street leading to the depot, contains 23.92 grains of solid matter to the gallon, containing alumina, sulphuric and muriatic acids, lime, magnesia and organic matter, both vegetable and animal. Mr. Askew's well contains to the gallon, 21.36 grains; organic matter 11.68; saline matter 9.68. The market well contains 18.80 grs. to the gallon; organic matter 7.20; saline matter 13.20.

The Doctor's well contains 21.44 grains of solid matter to the gallon, saline matter 8.16, organic matter 13.28.

To repeat once more, the saline matter in the foregoing wells consists of, 1, chlorides, or we may call them muriates, muriates of lime and magnesia; 2, sulphates, as sulphate of lime, together with organic matter. The saline matter is white and free from iron, or merely traces of iron. The brown or gray crust upon the tea kettles consists of the sulphates and carbonates of lime; the latter is formed probably from the organic salts.

The salutary effects of the spring water, which we have witnessed in several instances, is to be attributed to the iron, which is perfectly dissolved in the water when it issues from the fountain, in which condition it is readily absorbed into the system. The other substances, however, are regarded as aiding in the general effects.